VLF/LF TRACKING RECEIVER

SERIES 890

OPERATION & SERVICE MANUAL

AUSTIN, TEXAS

TRACOR INC.

PRELIMINARY

VLF/LF TRACKING RECEIVER

SERIES 890

OPERATION & SERVICE MANUAL

December 1964

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3364-0001

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TRACOR, Inc.
Manufacturing
WAlnut 60220

6500 Tracor Lane
Austin, Texas
78721

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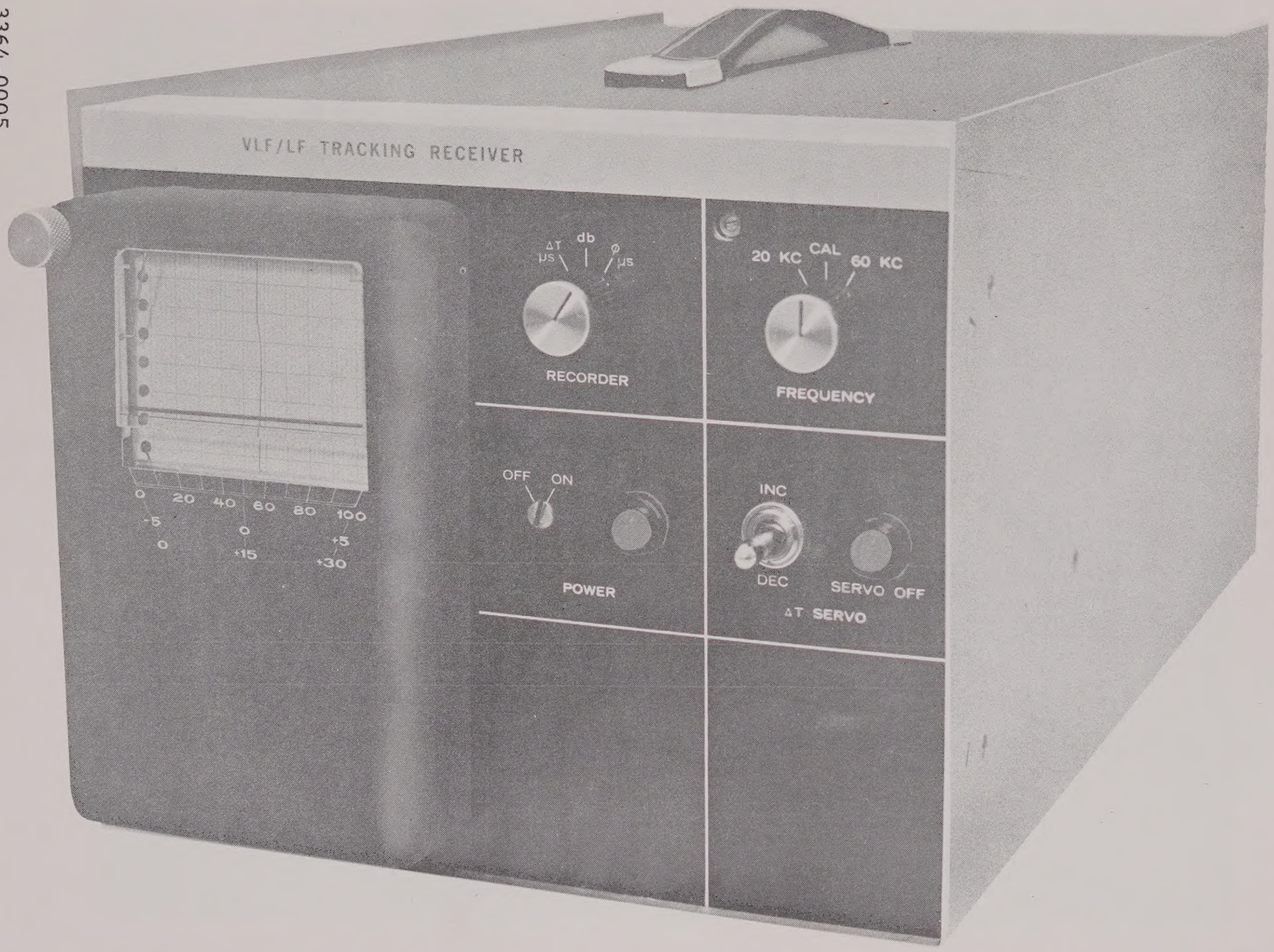

MODEL 890 VLF/LF TRACKING RECEIVER

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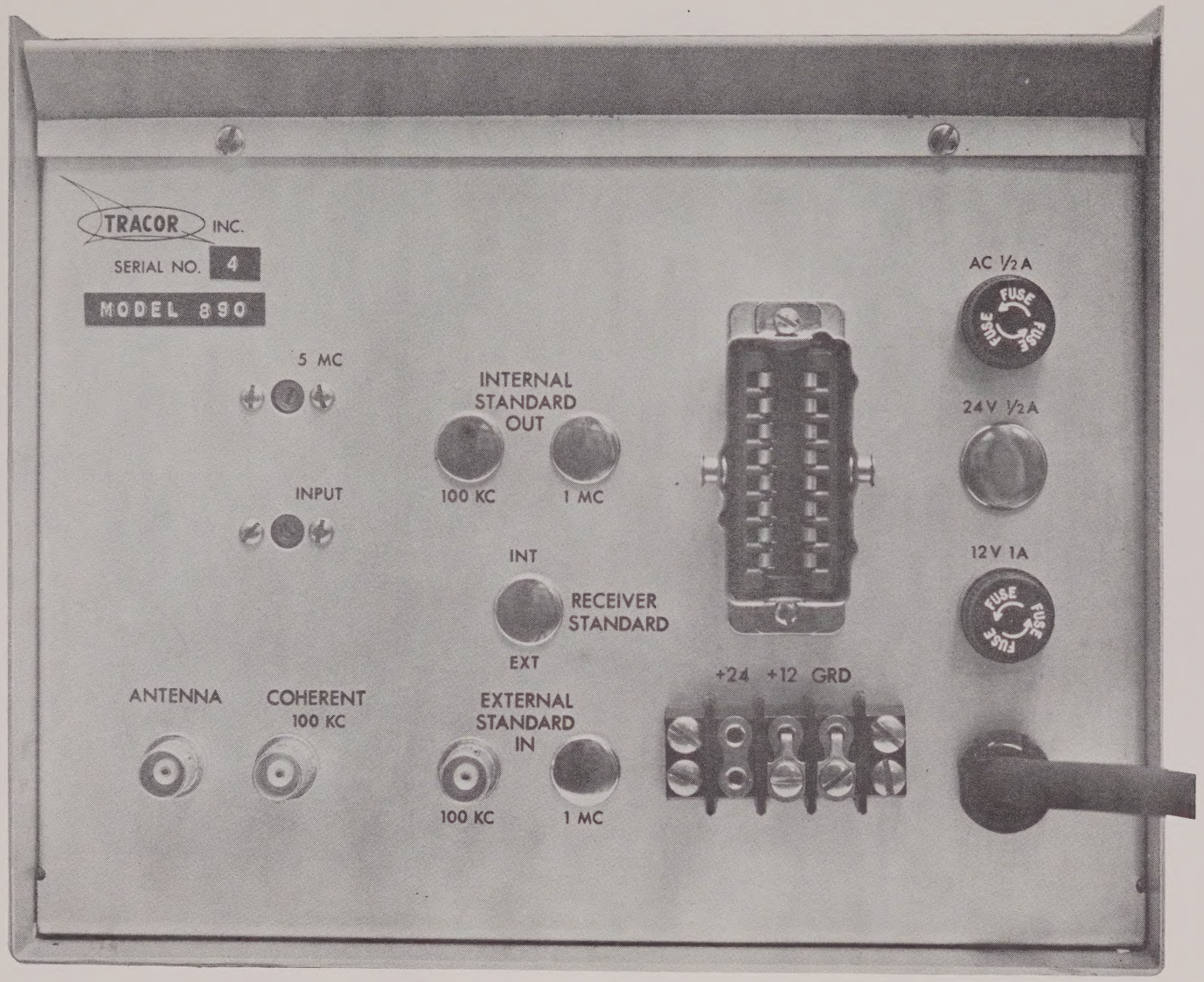

SERIES 890 BACK PANEL

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MODEL 892 VLF/LF TRACKING RECEIVER AND FREQUENCY STANDARD

I. INTRODUCTION

A. USFS

The United States national standard of frequency and uniform time is maintained at Boulder, Colorado, by the Boulder Laboratories of the National Bureau of Standards. This standard is called the United States Frequency Standard (USFS). As its name suggests, it is both common ground and final recourse in frequency determinations by private, civil and military groups in this country.

NBS radio stations WWVL (20 kc/s) and WWVB (60 kc/s) have been assigned the task of primary dissemination of USFS frequency. These stations are located near Fort Collins, Colorado. Figure 1-1 shows how radio signals emanating from them are related to the USFS. This system keeps WWVL and WWVB radio signal carrier frequencies very close to equivalent USFS values. In this way, NBS makes available radio signals of great stability and the very highest order of accuracy.

Because of the stability and dependability of 20 kc/s and 60 kc/s propagation, users throughout the continental United States receive these signals with nearly undegraded accuracy.

B. Series 890 VLF/LF Receivers

TRACOR's Series 890 receivers make frequency calibration and standardization in terms of the USFS easy, straightforward and inexpensive.

The basic unit in the series is the Model 890, a true phase-tracking receiver designed to receive WWVB and WWVL standard frequency transmissions.

Adding a Sulzer Laboratories 1 Mc/s frequency standard to the basic Model 890 unit results in the Model 892 Frequency Standard and Tracking Receiver unit.

Operation of the 890 family of instruments is extremely easy. Installation requires only situating the antenna suitably and supplying power (plus local standard signal for units without the internal standard). Tracking acquisition of the selected 20 kc/s or 60 kc/s carrier is automatic; in fact, attention to the integral chart recorder is all that is required in normal service.

All receivers in the family employ TRACOR's unique all electronic phase-tracking servo system for maximum performance, flexibility, reliability and convenience in operation.

A solid-state carrier relay circuit disables the electronic servo when the signal leaves the air. While the signal is absent, phase memory is retained in the electronic servo system without servo wander or drift, allowing smooth resumption of tracking when the carrier returns.

An internal calibration feature facilitates measuring the frequency of a local standard, with an accuracy limited only by propagation and transmitter uncertainties.

All units are equipped with a miniature stripchart recorder for making permanent records of local standard phase.

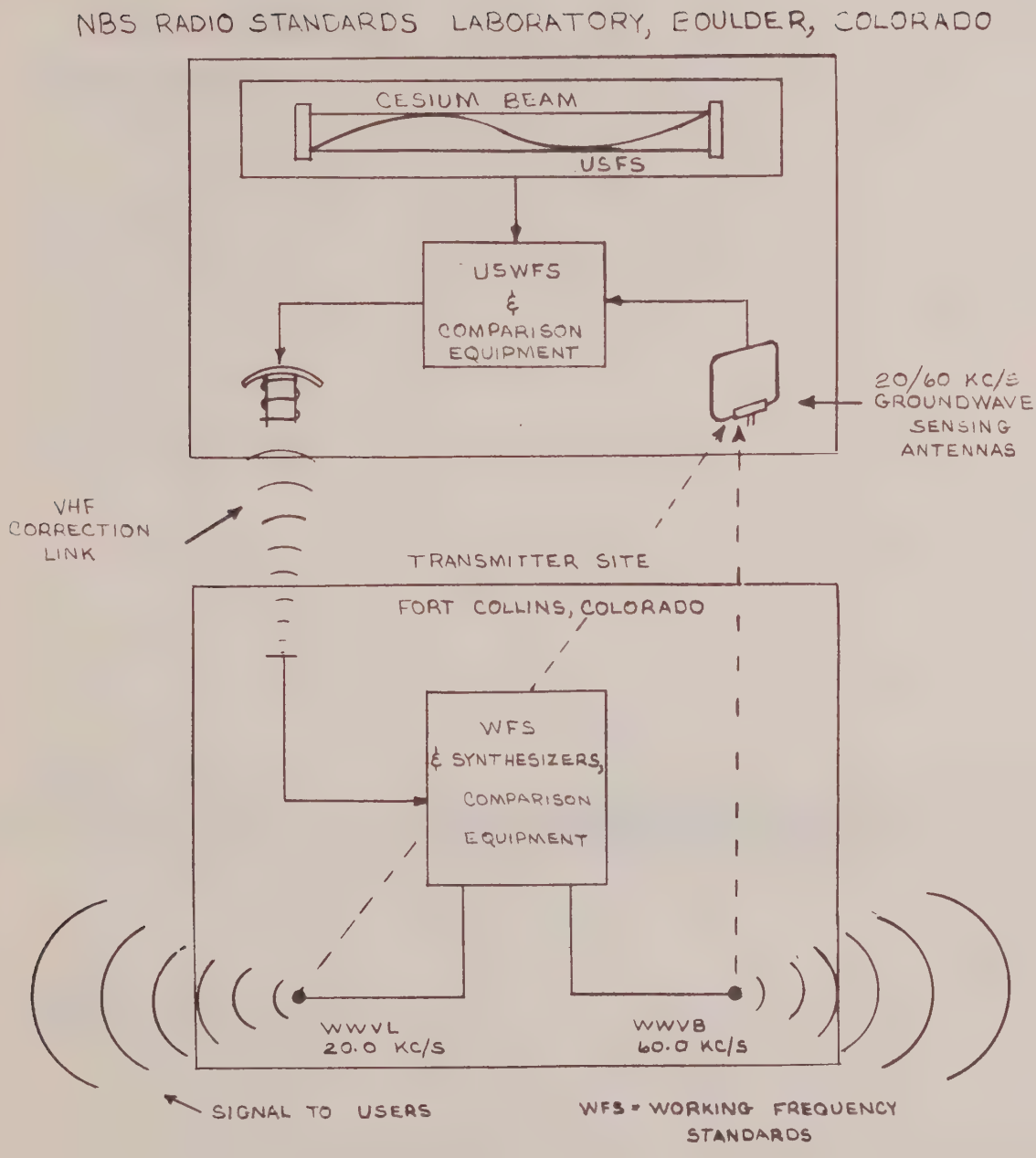

NBS RADIO STANDARDS LABORATORY, BOULDER, COLORADO
CESIUM BEAM
USFS
USWFS
&
COMPARISON
EQUIPMENT
20/60 KC/S
GROUNDWAVE
SENSING
ANTENNAS
VHF
CORRECTION
LINK
TRANSMITTER SITE
FORT COLLINS, COLORADO
WFS
& SYNTHESIZERS,
COMPARISON
EQUIPMENT
WWVL
20.0 KC/S
WWVB
60.0 KC/S
SIGNAL TO USERS
WFS = WORKING FREQUENCY
STANDARDS

Fig. 1-1

II. SPECIFICATIONS

Frequency Coverage	Tracks stabilized carriers at 20.0 kc/s or 60.0 kc/s, as selected by switch, for frequency calibration treaceable to NBS.
Sensitivity	Sensitivity is adequate to permit reliable phase tracking at any point in the continental U.S. Tracking threshold (when used with antenna supplied) is 30 μv/m at 20 kc/s and 10 μv/m at 60 kc/s.
Calibration Accuracy	Frequency calibration accuracy with respect to the transmitted signals better than $\pm 5 \times 10^{-11}$ (24-hour averaging) is possible under typical laboratory conditions. An internal calibration feature is provided to allow calibration with an accuracy limited only by propagation and transmitter uncertainties.
Antenna	Shielded 35 x 35 inch loop antenna (optimum for most environments) is supplied with receiver. Antenna requires no retuning or reorientation in normal operation, and may be mounted up to several hundred feet from receiver.
Display and Recording Capability	Built-in chart recorder provides meter display and permanent chart record for documenting calibrations. Front panel selector switch selects three receiver parameters for recording/ display:

a. Cumulative phase difference (normalized to microseconds) between local frequency standard and received 20 kc/s or 60 kc/s carrier; full scale represents 100 microseconds equivalent phase change.
b. Relative carrier level: range approximately 0 to 30 db.
c. Phase detector output voltage: scale (calibrated to read directly for corrections at 20 kc/s) represents -5 to 0 to +5 μsec (20 kc/s), or -1 2/3 to 0 to +1 2/3 μsec equivalent phase difference at 60 kc/s.

Noise Suppression

Unique noise limiter circuit provides floating limit threshold to permit low level limiting on impulse noise, without substantial suppression of carrier, in the presence of high-level CW interference.

Power Requirements

Normal operation: 115 volts ac ±10%, 48-62 c/s. Standby battery operation: +10 to +14 volts dc at 400 ma. Operation of chart drive motor is not sustained in battery operation. Chart drive is calibrated for 60 c/s operation.

Inputs

a. 100 kc/s standard frequency: 0.5 to 5.0 volts rms (1 Mc/s optional).
b. Remote command servo disable input: external ungrounded switch contacts may be used to stop phase servo.

Model 892	Adds a 1 Mc/s frequency standard to the basic Model 890 Receiver package.
Oscillator	Sulzer Laboratories Model 1B. Stability: $\pm 2 \times 10^{-9}$ per 24 hours. Front panel fine frequency adjustment is calibrated in parts in 10^{10} per minor division, nominal.

III. INSTALLATION AND OPERATION

Installation and operation of the Series 890 Receiver is easy and straight-forward.

Upon receipt of the equipment, unpack it and examine for damage. If damage is detected, file a claim with the carrier.

Install the loop antenna at some convenient place out of doors, preferably several feet from pipes or other conducting structures. Orient the plane of the loop so that it passes through the WWVL/VB transmitter location at Ft. Collins, Colorado. Approximate true bearings for several locations are given in Table I.

TABLE I

Area	Orientation (True)
Los Angeles	55°
San Francisco	73°
Houston	325°
New Orleans	315°
Chicago	270°
Cape Kennedy	305°
Washington, D. C.	285°
New York	280°
Boston	275°

Mount the receiver or receiver/frequency standard unit on a bench or table, or attach the optional rack mount fittings to the unit and rack mount it, as desired. For best stability, the unit should be placed where neither extreme nor widely variable temperatures are likely to be encountered.

Connect the loop antenna to the ANTENNA input of the receiver with a suitable length of RG-58/U cable. A cable length of several hundred feet is permissible.

Making sure the POWER switch is OFF, connect the unit to a source of 115 volts, 60 c/s nominal line power, and if desired, connect standby batteries as indicated to the rear panel. Standby power for units including the internal standard must be connected as shown in Figure 3-1.

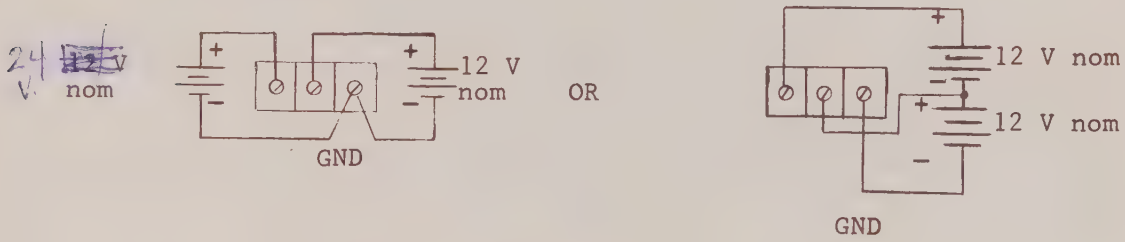


Figure 3-1

A. Model 890

Connect the local frequency standard voltage (at the proper frequency) to the unit at the EXTERNAL STANDARD IN connector on the back panel.

Turn POWER ON, and select the desired signal frequency (20 kc/s or 60 kc/s). If a signal is present, phase acquisition and tracking will be accomplished automatically, and presence of the signal will be indicated by the SERVO OFF lamp remaining off. (NOTE: Under some experimental broadcasting schedules, WWVL may transmit at 20.0 kc/s for several seconds, then transmit nothing at 20.0 kc/s for a while, then resume transmitting at 20.0 kc/s, etc. In this and similar cases, the SERVO OFF lamp might not remain off continuously. However, proper tracking will not be disturbed, since the carrier relay feature will simply lock up the phase-tracking servo during periods when there is no carrier.)

B. Model 892

If operation of the receiver on an external local standard is desired, switch RECEIVER STANDARD to EXT (back panel), connect a 1 Mc/s frequency standard voltage to 1 MC EXTERNAL STANDARD IN, and follow instructions under Model 890 above. (NOTE: When operating on an external standard, 1 MC INTERNAL STANDARD OUT remains connected to the internal Sulzer standard, but 100 KC INTERNAL STANDARD OUT is derived from the external standard.)

If operation of the receiver on the internal standard is desired, switch RECEIVER STANDARD to INT, turn POWER ON, and wait several hours for the frequency standard to warm up.

Then select the desired signal frequency. If the frequency standard output is not excessively in error, phase acquisition and tracking will be accomplished automatically.

C. Relative Time Difference Record

The relative difference between time based on local standard frequency and time based on WWVL or WWVB frequency (as received) may be recorded by switching RECORDER to Δt μs. Full scale in this recording mode represents 100 μsec of time difference.

D. IF Alignment

After several hours of operation (when the unit has attained thermal equilibrium), switch RECORDER to Φ μs and FREQUENCY to CAL. The recorder reading should stand near midscale (Φ=0), indicating normal phase shift in the receiver. If it does not, phase of the receiver can be noramlized by adjusting chassis capacitor C7 (on the front panel above and to the left of the FREQUENCY switch; use the insulated alignment tool provided with the receiver unit).

E. Making a Frequency Calibration

Fundamental USFS frequency is defined in terms of the "Ephemeris Second." This second, which carries the weight of

international agreement, is derived from the earth's period of rotation about the sun.

Most carrier-stabilized VLF transmissions, including those from WWVL and WWVB, are nominally based on the UT2 "Universal Time" second derived from the length of the solar day averaged throughout the year. Initially, the UT2 second and the second of Ephemeris time stood in agreement. Over the years, however, the UT2 second has become somewhat longer than the Ephemeris second, due chiefly to slowing of the earth's rotation because of lunar tide frictional losses and a number of related phenomena. In 1964, for example, the UT2 second is expected to run approximately 150 parts in 10^{10} longer than the Ephemeris second.

In the case of WWVL/VB, the offset during 1964 is exactly -150×10^{-10}. In 1965, the WWVL offset continues at -150×10^{-10}. WWVB, however, will be transmitted without offset (0×10^{-10} relative to the USFS). (In coming years, other values may be adopted; persons receiving the NBS bulletins mentioned below will be informed of impending changes.)

Existence of the offset should accordingly be recognized in making calibrations in terms of the WWVL/VB broadcasts. For example, the results of a calibration could be expressed as "-3.7×10^{-10} with respect to WWVL," or equivalently, as "-153.7×10^{-10} with respect to the USFS."

1. Corrections to WWVL/VB Broadcast Frequencies

Bulletins from which corrections to WWVL/VB broadcast frequencies may be obtained, along with broadcasting schedules and other useful information, are available to interested groups on request. Requests for this information should be addressed to

Frequency/Time Broadcast Services
Code 251.02
National Bureau of Standards
Boulder Laboratories
Boulder, Colorado

Bulletin data conventionally takes ~~this~~ the form of 24-hour average offset of broadcast WWVB/VL frequency from USFS frequency, with specified uncertainty, thus

FMW-1 OCTOBER 28, 1964 No. 25-64

DEVIATIONS 1/ OF THE FREQUENCIES BROADCAST BY STATIONS WWV (HF), WWVB (60 kHz) AND WWVL (20 kHz) WITH REFERENCE TO THE UNITED STATES FREQUENCY STANDARD.

1964		WWV	WWVB/WWVL	1964		WWV	WWVB/WWVL
SEPT.	26	-150.0	-150.0	OCT.	4	-149.9	-150.0
	27	-150.0	-150.0		5	-149.9	-150.0
	28	-150.0	-150.0		6	-149.9	-150.0
	29	-150.0	-150.0		7	-150.0	-150.0
	30	-150.0	-150.0		8	-150.0	-150.0
OCT.	1	-149.9	-150.0		9	-150.1	-150.1
	2	-149.9	-150.0		10	-150.1	-150.1
	3	-149.9	-150.0				

1/ PARTS IN 10^{10}. A MINUS SIGN INDICATES THE FREQUENCY WAS BELOW NOMINAL. WWV VALUES ARE 5-DAY RUNNING AVERAGES WITH AN UNCERTAINTY OF $\pm 5 \times 10^{-11}$ BASED ON RECEIVED SIGNALS OF WWVB AND WWVL IN TERMS OF THE USFS. THE VLF SIGNAL DEVIATIONS ARE 24 HOUR AVERAGES WITH AN UNCERTAINTY OF $\pm 2 \times 10^{-11}$ FOR THE PERIOD ENDING AT 1800 UT.

USCOMM - NBS - BL

Figure 3-2

2. Basic Computation

The basic relationship used in calibrating frequency standards by phase-tracking receivers is

$$\frac{\Delta f}{f} = \frac{\Delta t_2 - \Delta t_1}{T_2 - T_1} \qquad (1)$$

where T_1 and T_2 are the times at the beginning and end, respectively, of an observation period.

Δt_1 and Δt_2 are relative time differences measured by the receiver at T_1 and T_2 respectively, in the same units as T_1 and T_2.

$$\overline{\frac{\Delta f}{f}}$$

is average fractional frequency difference (error, offset, etc.) between the local standard and radio signal frequencies.

In Series 890 Receivers, circuits are arranged so that increasing indicated Δt corresponds to local standard frequency higher than WWVL/VB frequency; that is,

$$\overline{\frac{\Delta f}{f}}$$

is positive when local standard frequency is higher than WWVL/VB frequency.

As an example to show the use of (1), suppose that the Δt record reads +17.5 μsec on August 13, at twelve noon, and on the following day at noon, the reading is +68.5 μsec. Then the average apparent frequency offset for that particular 24-hour (86,400 seconds) period is

$$\overline{\frac{\Delta f}{f}} = \frac{(68.5 - 17.5) \times 10^{-6} \text{ sec}}{8.64 \times 10^{4} \text{ sec}}$$

$$\overline{\frac{\Delta f}{f}} \approx +5.8 \times 10^{-10}$$

Thus, the local standard is approximately 5.8 parts in 10^{10} high in frequency, relative to the NBS signal.

When suitable precautions concerning "cycle skipping" are observed, the above computation will yield results that are accurate within $\pm 5 \times 10^{-11}$ of USFS frequency, as received, if averaging takes place over a 24-hour period that begins and ends when transmitter and receiver locations are separated by an all-daylight path.

When greater accuracy is required, corrections discussed under the next heading should be used.

3. Methods and Corrections for Highest Accuracy

Several factors must be considered when attempting to achieve ultimate accuracy in frequency calibration.

a. Cycle Skipping

First, a continuous tracking record covering several days should be obtained, to help identify "cycle skips" that sometimes occur. Cycle skipping is normally the result of interference between different propagation modes and is most often seen at sunrise or sunset. The likelihood of cycle ckips varies from time to time during the year and is greater at 60 kc/s than at 20 kc/s.

A typical tracking record is shown in figure 3-3. In this 60 kc/s record, a cycle skip occurs at sunset. Observation of the daytime slope of the Δt record clearly indicates that a phase decrease of exactly one cycle has occurred; thus, one cycle of phase (16.67 μsec) should be added to any readings taken later, to allow for the skip. Skipping usually amounts to one cycle, although occasional skips of two full cycles are observed between one day and the next. Magnitude of the correction is $n \cdot 50$ μsec at 20 kc/s (n skips) and $n \cdot 16.67$ μsec at 60 kc/s.

b. Receiver Correction

The TRACOR Series 890 Receiver, like other receivers, may require correction for drift due to changing component temperatures, etc. For maximum calibration accuracy, it is recommended that the calibration feature incorporated in the unit be used for this purpose.

To obtain the correction for a value of Δt at a particular time, swtich FREQUENCY to CAL and RECORDER to Φ μs, and note the reading. For 20 kc/s, this scale reads out the correction directly in microseconds, and the correction indicated by it should be added to the value of Δt obtained at that time. For 60 kc/s, the scale reading should first be divided by three and then added to the concurrent value of Δt.

Expression (1), modified to encompass this correction, is then as follows:

(2) (for 20 kc/s)

$$\overline{\frac{\Delta f}{f}} = \frac{[(\Delta t_2+\delta t_2) - (\Delta t_1+\delta t_1)] \times 10^{-6}}{T_2 - T_1}$$

(for 60 kc/s)

$$\overline{\frac{\Delta f}{f}} = \frac{[(\Delta t_2+\frac{\delta t_2}{3}) - (\Delta t_1+\frac{\delta t_1}{3})] \times 10^{-6}}{T_2 - T_1}$$

where Δt_1, Δt_2, etc., are as before (with units of microseconds) and δt_2 and δt_1 are read from the Φ μs scale, as outlined above.

4. Local Frequency in Terms of the USFS

Final correction of local standard frequency calibration is made by using NBS bulletin data of the type shown in figure 3-2, as follows:

(4)
$$\overline{\frac{\Delta f}{f}}_{(USFS)} = \overline{\frac{\Delta f}{f}} + \frac{\Delta F}{F}$$

where

$$\overline{\frac{\Delta f}{f}}$$

is the corrected difference between local standard frequency and WWVL or WWVB frequency, obtained from expression (2) or (3); and

$$\frac{\Delta F}{F}$$

is the appropriate value of WWVL or WWVB offset, obtained from the bulletin.

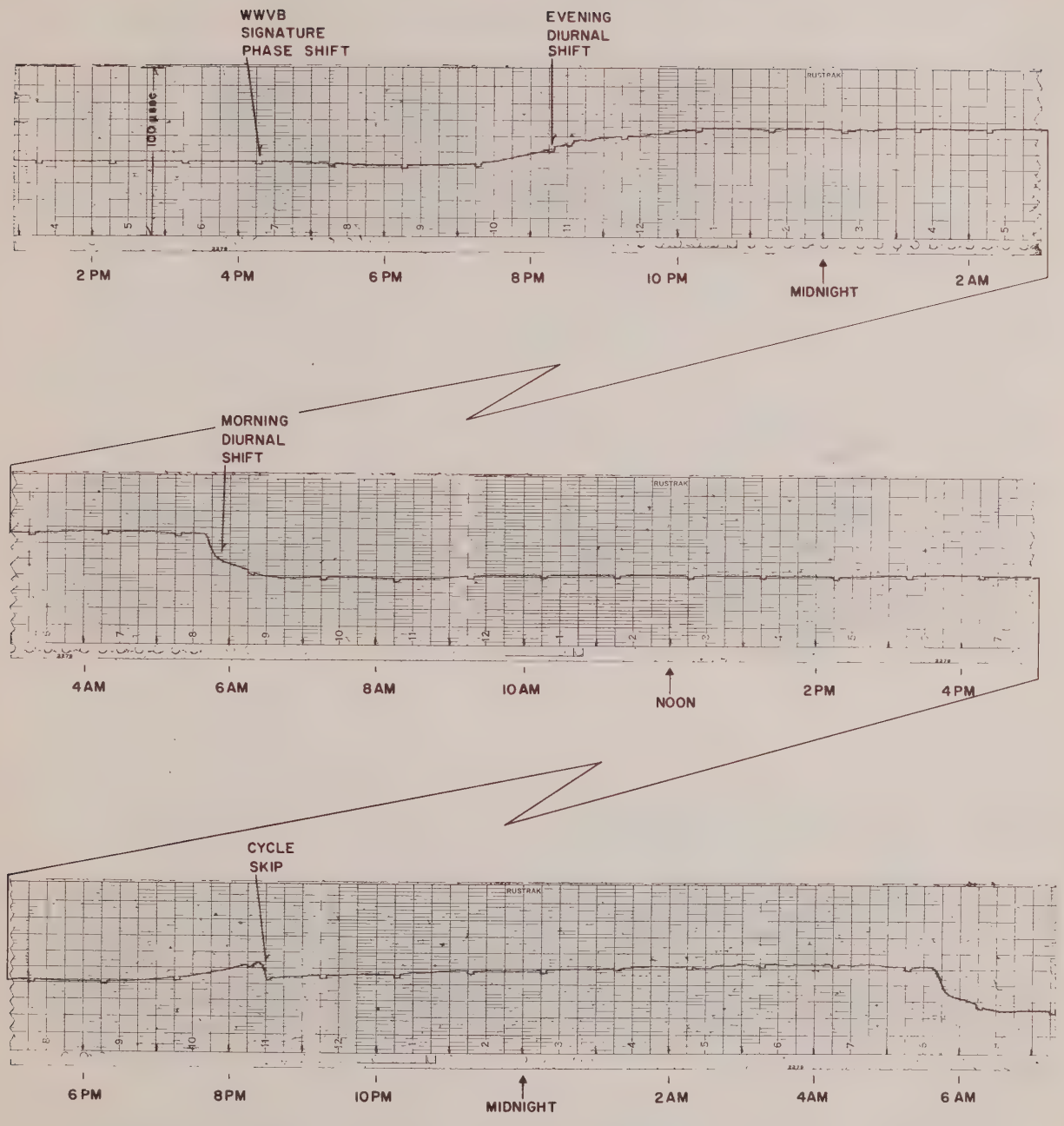


FIGURE 3-3 TYPICAL TRACKING RECORD AT 60kc/s

IV. THEORY OF OPERATION

A. Basic System Operation

The Series 890 Receiver makes use of the phase-tracking principle illustrated in basic form in figure 4-1. In this illustration the signal and local standard frequencies are, for simplicity, considered to be the same. In the actual system, of course, frequency translation and synthesis are employed to give the same result.

Signal phase Φ_s is compared to local standard phase Φ_L after phase shifter phase Φ_ϵ is added to Φ_L, giving an "error" voltage that corresponds to $\Phi_s - (\Phi_\epsilon + \Phi_L)$. The phase shifter operating rule is that Φ_ϵ changes in such a way as to make $\Phi_s - (\Phi_\epsilon + \Phi_L)$ approach zero. Under equilibrium conditions, then,

$$\Phi_s - (\Phi_\epsilon + \Phi_L) = 0,$$

or

$$\Phi_s - \Phi_L = \Phi_\epsilon$$

Φ_ϵ, the difference between local and signal phases, is obtained as an analog voltage readout from a phase comparator circuit that compares phase shifter input and output phases.

B. Detailed System Operation

Figure 4-2 shows detailed operation of the 890 receiver.

1. RF-IF System

A 20 kc/s or 60 kc/s signal received by the antenna is amplified and filtered in an RF preamplifier section. Passband of the RF system includes 20 kc/s and 60 kc/s; rejection band includes IF frequency (100 kc/s) and image response frequencies.

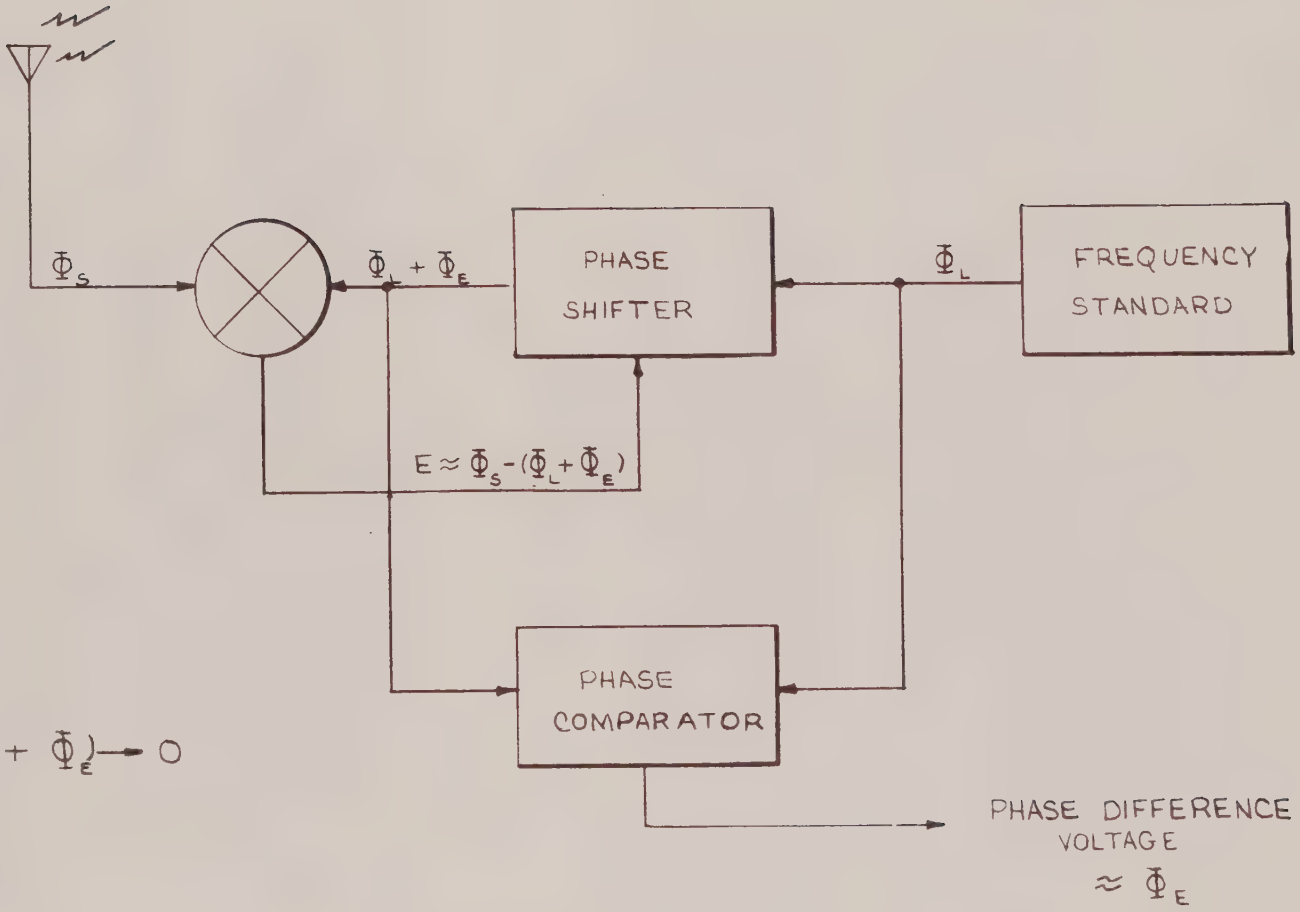


Fig. 4-1: BASIC PRINCIPLE OF SERIES 890 VLF/LF PHASE-TRACKING RECEIVER

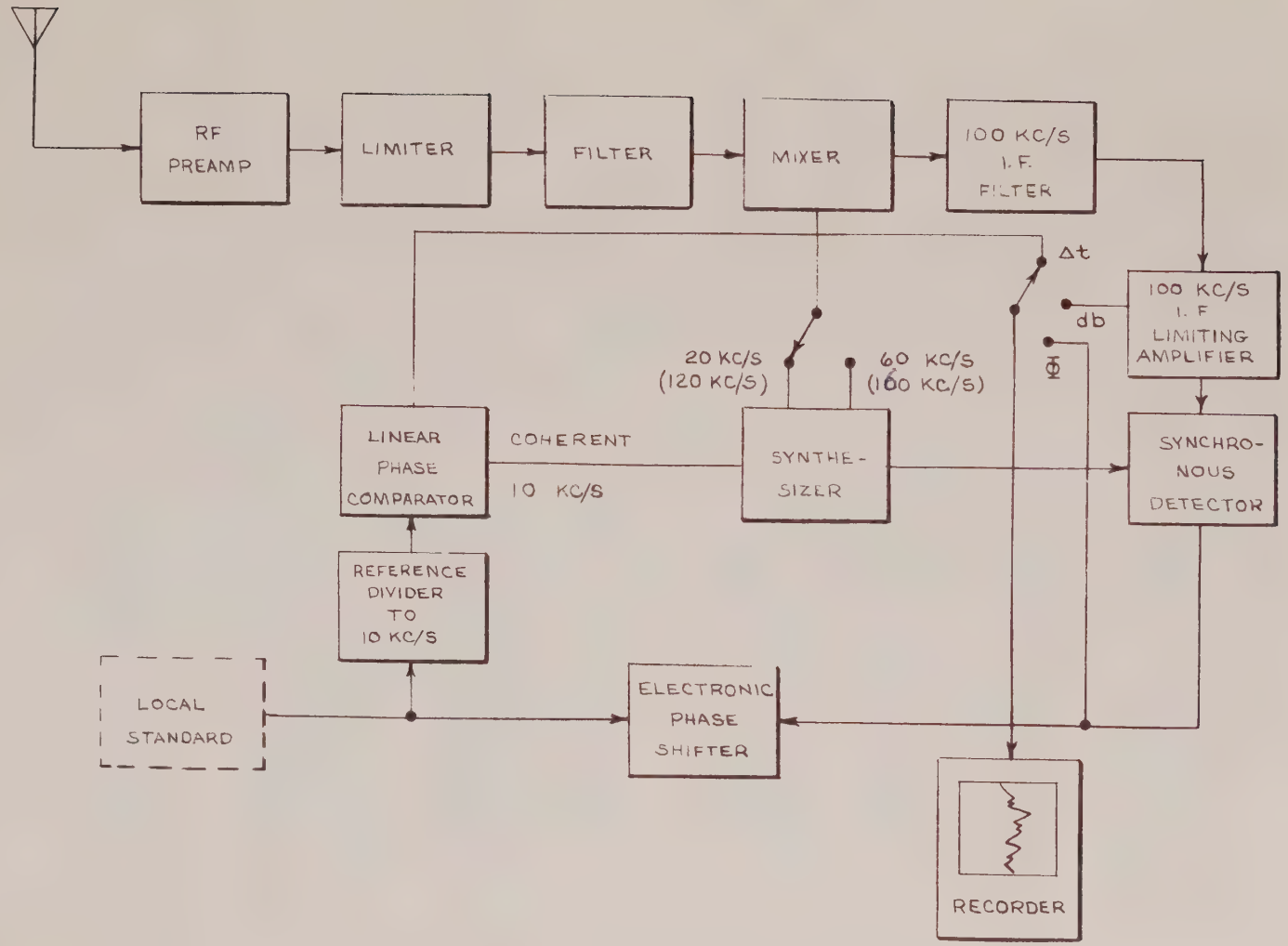


Fig: 4-2 DETAILED OPERATION OF THE SERIES 890 VLF/LF PHASE TRACKING RECEIVER

After preamplification, the signal passes through a limiter circuit that attenuates noise impulses. Conversion to an intermediate frequency or 100 kc/s is accomplished in a balanced mixer circuit that attenuates any 100 kc/s voltage coming originally from the antenna.

Conversion of the 20 kc/s signal to 100 kc/s IF is accomplished by injecting 120 kc/s local oscillator (LO) voltage into the mixer; 160 kc/s is injected for 60 kc/s reception.

After conversion, the signal is filtered by a narrow-band crystal element, and amplified by an IF amplifier to a level appropriate to synchronous detection.

The IF amplifier is composed of a number of cascaded stages that act at low levels as linear amplifiers and at higher levels as symmetric limiting amplifiers. They are designed so as not to introduce appreciable phase shift when undergoing the transition from linear to saturated amplifier operation.

After amplification, synchronous phase detection of the amplitude-limited signal produces the phase error voltage that actuates the electronic phase shifter for phase tracking. This voltage may be monitored on the chart recorder if desired. The 100 kc/s output of the synthesizer that follows the electronic phase shifter serves as the detector reference voltage.

When amplifiers in the IF chain act as limiters, dc voltages indicative of carrier strength are generated. Voltages of this type arising in the last few IF stages are summed in a resistive network to provide a roughly logarithmic index of carrier strength, which may also be monitored or recorded.

Carrier level dc voltage from the last IF stage is compared to a threshold in a carrier detector circuit, and the resulting output is used to lock up the electronic servo in event of apparent lost carrier.

2. Synthesizer-Servo System

100 kc/s voltage for system operation is taken from an external 100 kc/s standard, or from an internal frequency divider if the internal 1 Mc/s standard (Model 892) or an external 1 Mc/s standard is employed.

100 kc/s voltage thus obtained is taken in parallel into the electronic servo and into the reference frequency divider. In the latter, a pulse train at 10 kc/s is obtained for use in the 100 μsec phase comparator. In the former, the 100 kc/s input is processed to provide the basis for a phase-shifted 100 kc/s output for use as the synchronous detector reference voltage.

Voltages for LO injection, 100 μsec phase comparator operation, etc., are obtained from the synthesizer section, whose input is obtained from the electronic servo.

C. Circuit Operation

Refer to Diagrams 71, 72 and 74 in Chapter IX.

1. RF-IF Circuits

The RF signal entering the receiver is coupled through T1 into the RF preamplifier circuit, which consists of Q1, Q2, Q3 and associated components. T1 serves the purposes of isolating input and preamplifier ground circuits and of transforming antenna impedance to a value appropriate for driving Q1. Stabilizing ac gain of the input circuit and achieving approximately 50 ohms input impedance are accomplished by negative feedback from output to input through R1. Bias stabilization of the input preamplifier results from dc feedback through R2. This feedback holds output operating point voltage very near +4.5 volts.

The RF signal appearing at the output of the RF preamp (collector of Q3, TP-1) is then conducted to an impulse limiter circuit using Q4 and Q5. These transistors are connected to act as high conductance rectifiers.

In normal operation, C4 and C5 potentials are quite near +4.5 volt bus voltage, and no current flows in Q4 or Q5 since signal voltages at the limiter input are not large. When a large noise impulse occurs, however, limiter input voltage exceeds Q4 or Q5 contact potential, causing conduction and "draining off" of the bulk of the impulse into C4 or C5.

If a large CW signal (as from a nearby station) appears at the input of the limiter, C4 and C5 gradually charge up, in effect raising the threshold at which limiting action begins and preventing substantial suppression of the desired 20 kc/s or 60 kc/s signal. Jumper J1 may be removed if limiting action is not desired.

Emitter follower Q6 couples limiter output into the RF filter assembly, which includes L1, L2, C6 and C7. This filter is relatively flat below 40 kc/s, rises to a peak of response at 60 kc/s, and drops to a minimum at approximately 100 kc/s. Overall input circuit response continues to drop above 100 kc/s, to assure reduced response at image frequencies.

Output of the filter is amplified by Q7 and Q8, which present balanced out-of-phase signal voltages to mixer transistors Q9 and Q10. Q9 and Q10 bases are heavily driven out-of-phase by LO voltage (at 120 kc/s for 20 kc/s reception, or 160 kc/s for 60 kc/s reception) so that these transistors act in effect as choppers in a balanced mixer circuit.

Signal voltage at 100 kc/s is taken from the mixer through summing resistors R16 and R17 to front panel FREQUENCY switch S3; from this switch the signal returns (when S3 is in 20 kc/s or 60 kc/s positions) to the first IF amplifier transistor Q18.

Q18 drives crystal filter Y1 through tuning capacitors C6 and C7 (Dwg. 74). The filter output signal returns to common base amplifier Q19 through R71.

Because of shunt capacity of the crystal filter element (≈40 pf), signals remote from 100 kc/s can also pass through the filter unit, although with considerable attenuation. To reduce feedthrough of possible adjacent channel interference, Q18 acts at frequencies other than 100 kc/s as a phase inverting amplifier, with the inverted output fed through C18 and C19 to cancel out feedthrough of filter shunt capacity. C19 is adjustable to allow exact balancing of filter feedthrough voltages.

The first IF stage output, at the collector of Q19, is coupled into the first of seven essentially identical IF amplifier stages, which use transistors Q20 through Q33. The second of these stages (Q22 and Q23) differs from the others in having a resonant output circuit and a gain control adjustment. The gain potentiometer in this stage is for adjusting tracking threshold level.

Stages employing Q24 through Q33 are designed to accept a wide range of signal levels without changing signal phase. In normal operation, gain of the amplifier is set (by adjustment of R59) so that the last stage is slightly saturated by minimum expected (threshold) signal; progressively larger signals saturate progressively more amplifiers toward the IF input stage.

Following amplification by IF stages, the signal appears in the collector of the last stage output (Q33) as a square wave or current. This current is coupled through C14 to the collector of synchronous detector Q16. The base of Q16 is driven by a 100 kc/s reference voltage from the synthesizer circuits, so that Q16 acts as a phase detector chopper to convert the 100 kc/s signal into a dc error voltage at the output of a low pass filter consisting of R34 and C13.

Q14 and Q13 are connected to act as a high-gain

differential amplifier pair; when voltage at Q14 base is slightly positive relative to +4.5 volt bus, Q13 becomes non-conducting, and when Q14 base is slightly negative, Q13 conducts heavily and Q14 is off. Q13 and Q14 collector voltages are taken as "tracking instructions" to the electronic servo circuits described below.

2. Signal Level and Servo Lockup Circuits

When the last IF stage (Q32 and Q33) is driven into saturation by a signal, a positive dc voltage (on the average) is produced at the emitter of Q33. The reason for this is that when Q33 is overdriven, forward conduction in its base-emitter diode prevents appreciable negative-going voltage (relative to +4.5 volts bus) during negative-going input half-cycles of signal at the base of Q32. On the other hand, Q33 base-emitter diode opens up on positive-going half-cycles of input signals, allowing the emitter of Q33 to follow the input voltage quite closely. On the average, then, the dc voltage at the emitter of Q33 represents quite closely the excess of signal at the base of Q32 over the stage saturation level.

For an indication of signal level, voltages thus obtained from the last two stages are summed through R82 and R88 (and R76, if a wider dynamic range of carrier indication is desired) and transmitted at a low impedance by emitter-follower Q12 to the front panel for display or recording (switch S4 in db position). 0 db bias reference is furnished by a second emitter-follower, Q11.

Carrier bias from Q33 is also used to enable tracking. In the absence of a signal, Q34 is held on by bias current supplied by R90. Q34 collector current in turn holds Q17 on, lighting SERVO OFF lamp DS1 (collector of Q17) and biasing Q15 for conduction. When Q15 conducts, Q13 and Q14 collectors are tied together at a potential that is too low for electronic servo operation.

When a carrier is present, bias in R90 is overcome by the detected signal at Q33 emitter flowing in R89, turning Q34 off. This turns Q17 off, extinguishing the SERVO OFF lamp DS1 and opening Q15. When Q15 is non-conducting, normal differential amplifier action of Q13 and Q14 can occur, and normal servo steering voltages are transmitted to the electronic servo circuits from the collectors of Q13 and Q14.

3. 100 kc/s Input Circuits

100 kc/s frequency standard input voltage appears at terminal X, PCB 64A (Dwg. 72). Noise and other interference is reduced by a filter consisting of C29, L16 and C3. Amplitude of the 100 kc/s input voltage is then normalized for the remainder of the synthesizer by an emitter-coupled limiter amplifier incorporating Q1 and Q2. 100 kc/s outputs of the limiter stage are used for two purposes: to drive a reference divider chain circuit and to operate an electronic phase servo circuit.

4. Reference Divider Chain

This circuit reduces the 100 kc/s input to 10 kc/s to serve as "local standard" reference input for a linear phase comparator circuit.

100 kc/s voltage at the collector of Q1 is coupled to the base of pulse-forming amplifier Q7, alternately driving Q7 into saturation and cutting it off. The waveform at the junction of R33, R34 and the collector of Q7 is thus a train of rectangular pulses, as shown in figure 4-3. Pulses start at +4.5 volts (Q7 off) and terminate at +9 volts (Q7 saturated). These pulses are coupled, at reduced amplitude, as a reference to synchronous divider transistors Q8 and Q9 through a voltage divider consisting primarily of R34 and R36.

5. Frequency Divider Stage

(The following description applies to all synchronous dividers in the Series 890 circuits.)

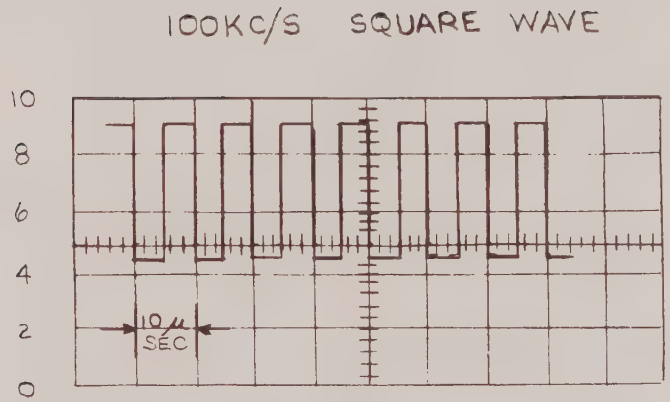


Fig. 4-3: WAVEFORM AT COLLECTOR OF Q7

100 kc/s reference voltage pulses of approximately 0.8 volts peak-to-peak amplitude thus appear at the base of normally non-conducting Q9. When Q9 is off, its emitter voltage is more positive than its base voltage. But due to the current flowing from ground into timing capacitor C9 through timing resistor R38, the base-emitter voltage difference continually diminishes. At this time Q8 is also off. Finally, a reference pulse at the base of Q9 increases emitter-base voltage above conduction threshold, causing collector current to flow in Q9. This initial surge of current flows in the base of Q8, turning that transistor on; in turn, Q8 collector current reinforces initial Q9 base current. This regenerative action continues as long as C9 can supply appreciable emitter current to Q9.

During the period of regenerative action and for a little while thereafter, the base of Q9 (and junction of R36, R34 and R35) rises from +4.5 to +9.0 volts, producing a pulse similar to the original reference pulse occurring at the collector of Q7. This pulse is in turn transmitted through R35 as a timing reference to the next stage (Q10 and Q11).

When regenerative action between Q8 and Q9 is finished, Q8 base potential returns to +4.5 volts, and C9 has been discharged so that the emitter of Q8 begins dropping from +9 volts as a new cycle starts.

Values of timing resistor R38 and timing capacitor C9 are chosen to give the proper cycle length. In this case, the cycle is as long as two reference pulses, so that division by two is accomplished. Other circuits in the Series 890 Receiver, mentioned below, use the same principle of operation to reduce frequency in ratios down to 1:5, with various output frequencies resulting.

Output of the reference divider chain is a short negative-going pulse at 10 kc/s, coupled through diode CR2 to the

base of phase comparator transistor Q42.

6. Electronic Servo Circuits

Operation of these circuits can best be understood with the aid of the functional diagram, figure 4-4.

Referring to the functional diagram as well as the schematic, Dwg. 72A in Chapter IX, we see that 100 kc/s standard input voltage is first normalized (reduced to uniform, predetermined amplitude and slope) by a limiter circuit using Q1, Q2 and C5.

From this normalized voltage, a 100 kc/s waveform is derived by an advance/retard (A/R) generator (Q3 and Q4) producing an output current at 100 kc/s, which varies in phase delay by a small amount in either direction relative to the normalized 100 kc/s input voltage. This is accomplished by adding a dc delay voltage to the normalized 100 kc/s driving voltage at the base of limiter transistor Q3 (or alternatively by adding it to the base of Q4).

Because of the accurately fixed slope of the 100 kc/s input voltage, a given dc bias thus applied will produce a small accurate advance (or delay) in the time at which the collector current switches from Q4 to Q3.

If dc voltage at the base of Q3 is increased, switching of current from Q4 to Q3 occurs earlier; if the voltage at the base of Q4 is increased, this transition occurs later. Figure 4-5 illustrates how this happens. Although it is evident that phase delays (or advances) obtained in this way must be limited to a fraction of a 100 kc/s cycle, such limitation does not apply to voltages related to the basic 100 kc/s by a high harmonic number. A 5 Mc/s voltage so related, for example, would change phase by a full 360 electrical degrees if the basic 100 kc/s voltage were advanced or retarded by only 0.2 μsec.

In a circuit following the 100 kc/s A/R generator, a harmonic enhancement multiplier generates a 5 Mc/s voltage of

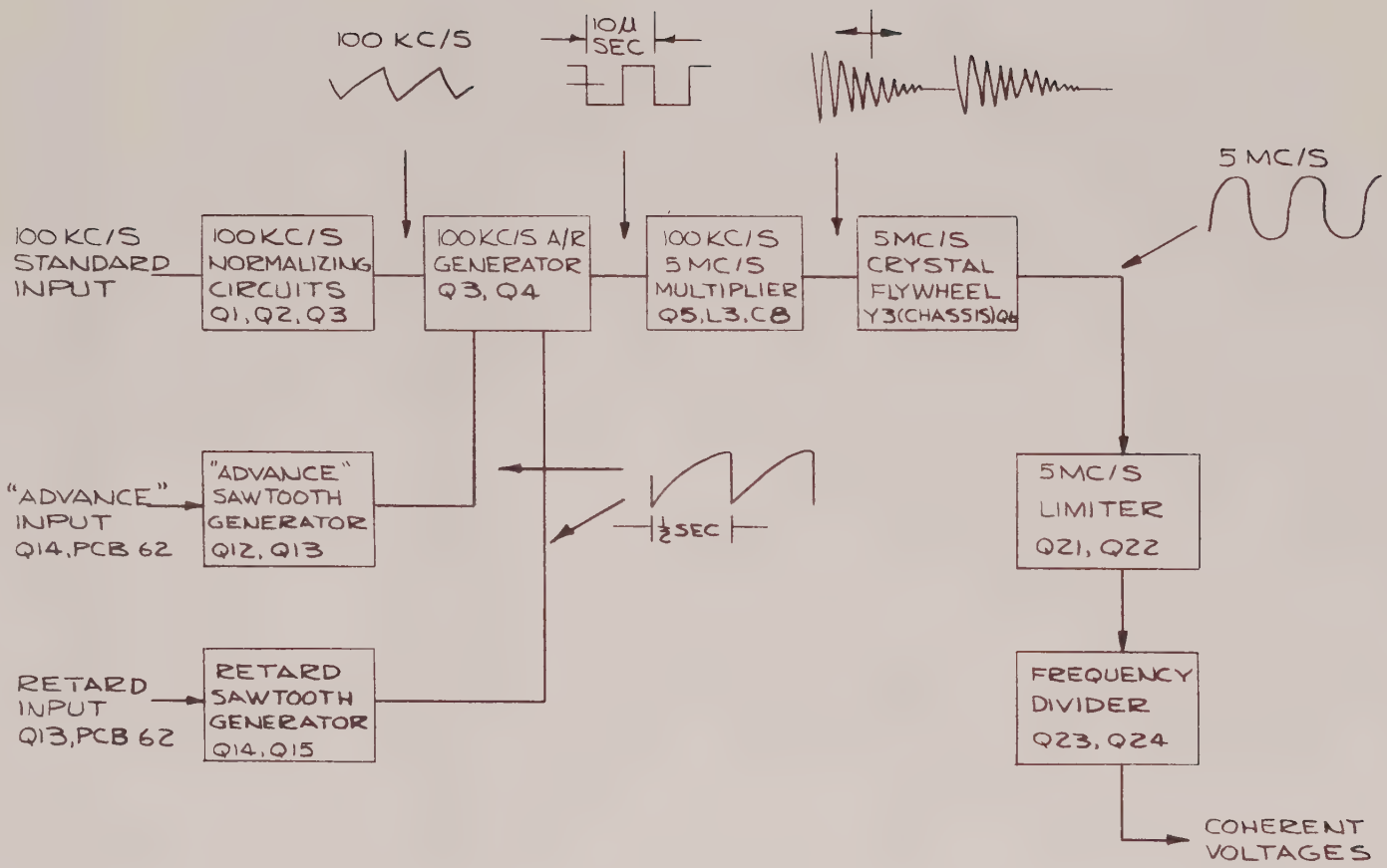

100 KC/S
10μ SEC
5 MC/S
100 KC/S STANDARD INPUT
100KC/S NORMALIZING CIRCUITS Q1, Q2, Q3
100KC/S A/R GENERATOR Q3, Q4
100 KC/S 5 MC/S MULTIPLIER Q5, L3, C8
5MC/S CRYSTAL FLYWHEEL Y3 (CHASSIS) Q6
"ADVANCE" INPUT Q14, PCB 62
"ADVANCE" SAWTOOTH GENERATOR Q12, Q13
½ SEC
5MC/S LIMITER Q21, Q22
RETARD INPUT Q13, PCB 62
RETARD SAWTOOTH GENERATOR Q14, Q15
FREQUENCY DIVIDER Q23, Q24
COHERENT VOLTAGES

Fig 4-4 BLOCK DIAGRAM OF ELECTRONIC SERVO PCB 64 A

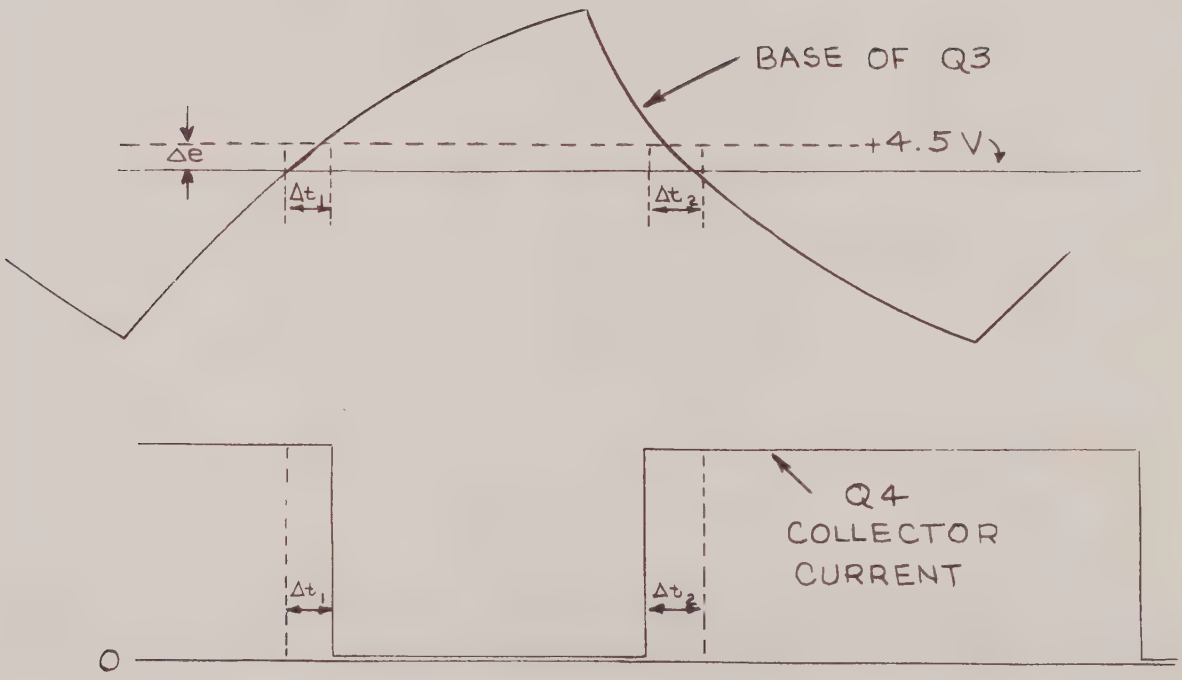


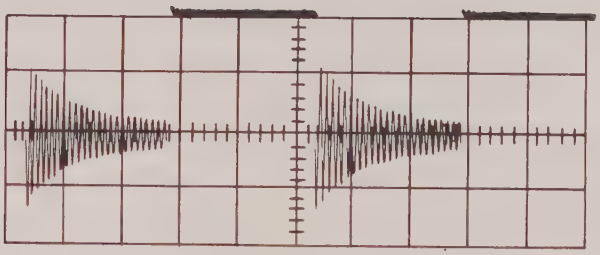
Fig 4-5 & 4-6: A/R GENERATOR WAVEFORMS

the type described above. This is done by using Q4 output current to switch Q5 on and off at a 100 kc/s rate; when Q5 conducts, charging current flows in L3, an inductor in a 5 Mc/s resonant circuit. When Q5 opens up on the next half of its 100 kc/s input cycle, the energy stored in L3 over the preceding half-cycle "rings" the resonator consisting of L3 and C8 at approximately 5 Mc/s. Figure 4-6 shows the waveform thus obtained. This train of damped 5 Mc/s waves is rich in a 5 Mc/s fourier component that is, of course, locked to the advance/retard generator 100 kc/s output; when the 100 kc/s phase, for example, is advanced or retarded 0.2 μsec, the 5 Mc/s component moves through 360 electrical degrees (one cycle) relative to the basic 100 kc/s input. The 5 Mc/s component of this voltage is isolated by a 5 Mc/s crystal filter circuit consisting of(chassis components) crystal Y3 and tuning capacitors C4 and C5. The output of the crystal is, of course, a relatively clean sinewave, which advances or retards relative to the 100 kc/s input.

"Advance" and "retard" sawtooth generators provide advance/retard voltages to the 100 kc/s A/R generator. In the absence of a phase error in normal tracking, these generators are biased to quiescence, and the generator output phase remains stationary relative to the 100 kc/s input.

But suppose that a tracking error exists that would result in delaying the servo phase. When this happens, the "retard" sawtooth generator feeds a sawtooth voltage to the A/R generator. Peak-to-peak amplitude of the sawtooth generator is very carefully controlled to produce a peak-to-peak A/R generator of exactly 0.2 μsec, i.e., one cycle at the 5 Mc/s crystal filter frequency.

The ascending portion of sawtooth voltage produces a slowly increasing delay (0.2 μsec in 1/2 sec) that the crystal filter "flywheel" follows easily. When the sawtooth drops back,



2 V/CM - 2 μSEC/CM

Fig. 4-7: WAVEFORM AT COLLECTOR OF Q5

however, the resulting transition in A/R output delay occurs so rapidly (≈ 1 μsec) that the flywheel (ringing time ≈ 1 msec) can not follow. The flywheel output therefore "stays put" and, since the delay dropback is exactly one cycle, output of the crystal filter continues without disturbance. In this way, each flyback of the retard sawtooth voltage marks a corresponding additional delay of 0.2 μsec, relative to the 100 kc/s input.

Advancing rather than retarding phase, of course, results from biasing the "advance" sawtooth generator for operation instead of the "retard" oscillator.

7. Coherent Divider and LO Synthesizer

After passing through a limiter (Q21 and Q22) and pulse-forming amplifier (Q23), the phase-locked output of the crystal flywheel at 5 Mc/s is reduced to 200 kc/s by two divider stages (similar to stages containing Q8, Q9, etc., described above) utilizing Q24, Q25, Q26 and Q27. Q28 inverts and amplifies the 200 kc/s pulse that appears at the base of Q26, and supplies the resulting positive-going pulse for emitter commutation of a binary frequency divider stage using Q35 and Q36. 100 kc/s voltages appear at the collectors of Q35 and Q36; emitter follower Q34 transmits Q35 collector voltage to receiver detector PCB 62 to act as synchronous detector reference (terminal Y), to the rear panel as COHERENT 100 KC output (terminal L) and to the front panel FREQUENCY selector switch (via terminal H).

The latter output serves as a calibration signal used in measuring the "phase" of the 100 kc/s IF amplifier, as described above.

Further frequency division in the main coherent divider chain produces 40 kc/s pulses at the base of Q31. Resulting collector current pulses "ring" tank circuit resonator elements L14, L15 and C26.

For reception at 60 kc/s, L14 is shorted out and the resulting circuit resonates at 160 kc/s (in this case the LO). For reception at 20 kc/s, L14 and L15 resonate with C26 at 120 kc/s.

Limiters Q40 and Q37 "square up" these LO voltages (and remove unwanted amplitude modulation components) and drive LO output switches Q38 and Q39, which in turn transmit the LO signal to mixer circuits on PCB 62.

8. Phase Comparator

Further division in the coherent divider chain by a stage employing Q32 and Q33 produces a pulse train at the base of Q32 at 10 kc/s. This train is, of course, locked in phase to the RF signal when the receiver is tracking.

The phase comparator circuit proper is a bistable set/reset flip-flop consisting of Q41 and Q42 and associated components. Reference pulses from the base of Q10 "set" the flip-flop; when this happens, the voltage at the collector of Q41 attains approximately +9 volts. When a second pulse, from the base of Q32 in the "coherent" divider chain, appears at the base of Q41, the flip-flop is "reset" and Q42 collector potential quickly drops to near ground level.

The rectangular wave obtained in this way at the collector of Q41 has a duty ratio that depends on the delay between these "set" and "reset" pulses, and its average voltage precisely represents the delay. Average value is obtained by low pass filter circuits consisting of R84 and R72, C24, R85 and C25. Voltage at C24 is used for operating the Δt recorder, and C25 voltage is taken to the back panel for external monitoring. R84 is used to calibrate the internal recorder for full scale.

V. MAINTENANCE AND ALIGNMENT

Periodic alignment or maintenance is not required in operating the Series 890 Receiver. The Model 892 may require occasional readjustment of its internal frequency standard (step 7 below).

To facilitate alignment in event of major component replacement, the following factory alignment procedures are given. Applicable steps should be performed in the order given.

1. Adjustment of 1 Mc/s Input Stage (for Model 892, and Model 890 with 1 Mc/s Adapter)

a) Mount PCB 69 (or PCB 66, 890 option) on card extender (other cards in place); then connect a 1 Mc/s standard to 1 MC EXTERNAL STANDARD IN.

b) Check voltage at the base Q1 with a Tektronix type 535 oscilloscope (or equivalent, with an input capacitance of 15 pf or less), and adjust C1 "input" capacitor (Dwg. 76A) at rear panel for maximum 1 Mc/s voltage. Use an insulated alignment tool when adjusting C1.

2. Adjustment of 5 Mc/s Servo-Flywheel Circuits

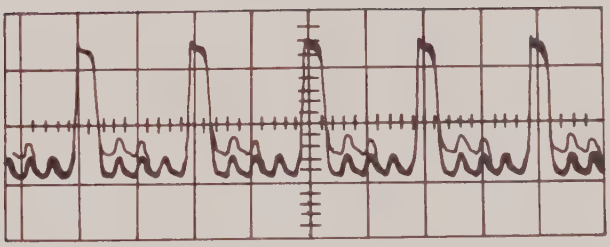
a) Mount PCB 64 on a card extender; then switch POWER ON (supply frequency standard voltage as available).

b) Using a Tektronix type 535 (or equivalent high frequency oscilloscope), monitor the 5 Mc/s voltage appearing at the base of Q21 (PCB 64). Use a probe with less than 15 pf capacitance.

c) Using the yellow alignment tool supplied with the receiver, adjust L3 for maximum 5 Mc/s voltage at monitored point.

d) Then use an insulated alignment tool to adjust C7 (rear panel, Dwg. 74A) to again achieve a maximum of 5 Mc/s Q21 base voltage.

e) Repeat (c) and (d) until no further improvement is possible.



2V/CM - .5μSEC/CM

Fig. 5-1: WAVEFORM AT BASE OF Q 25

3. Alignment of 5 Mc/s-1 Mc/s Divider Stage

This stage makes use of Q24 and Q25, and the division ratio is set for optimum operation by adjusting trimpot R55.

a) Mount PCB 64 on a card extender; connect frequency standard voltage into unit as appropriate, and switch POWER ON.

b) Connect the input of a Tektronix type 535 scope (or equivalent with frequency response to 15 Mc/s) to the base of Q25, and monitor the waveform there (figure 5-1). Use a 10x, 15 pf probe. Adjust scope trigger circuits for stable triggering on large pulses, and sweep speed for five large pulse periods (or about 25 small pulse periods) across scope face.

c) Adjust R55 so the divider circuit "counts by five," i. e., so a large pulse appears over every fifth small pulse.

d) Using a screwdriver or alignment tool, rotate R55 adjustment screw clockwise until the circuit counts by four. Then back R55 up just until circuit consistantly counts by five again. Note position of the adjustment screw.

e) Then continue turning R55 screw counter-clockwise, counting turns, until the circuit just starts dividing by six.

f) Return the screw to the position obtained in step (d).

g) Then rotate R55 screw counter-clockwise just half the number of turns determined in step (e). This completes alignment of the 5 Mc/s-1 Mc/s Divider circuit.

4. Adjustment of Δt Record Zero and Full Scale

a) Supply receiver circuits with frequency standard voltage, but not with antenna signal, and switch POWER ON.

b) Switch recorder to Δt. By means of Δt SERVO INC/DEC slewing switch, adjust Δt reading on recorder to minimum on recorder scale. This is done by setting the Δt reading just past

the point at which the record reading jumps from far upscale to near zero, as the Δt INC/DEC switch is momentarily operated.

c) Using the mechanical recorder zero control (in access hole at bottom of recorder panel), adjust the recorder to read zero. (The recorder will then normally read slightly below zero with receiver circuits off.)

d) In the same way rock the Δt INC/DEC switch until the Δt reading is just at full scale. Then adjust R84 (near top of PCB 64) so that the Δt record reads exactly full scale (100 μsec).

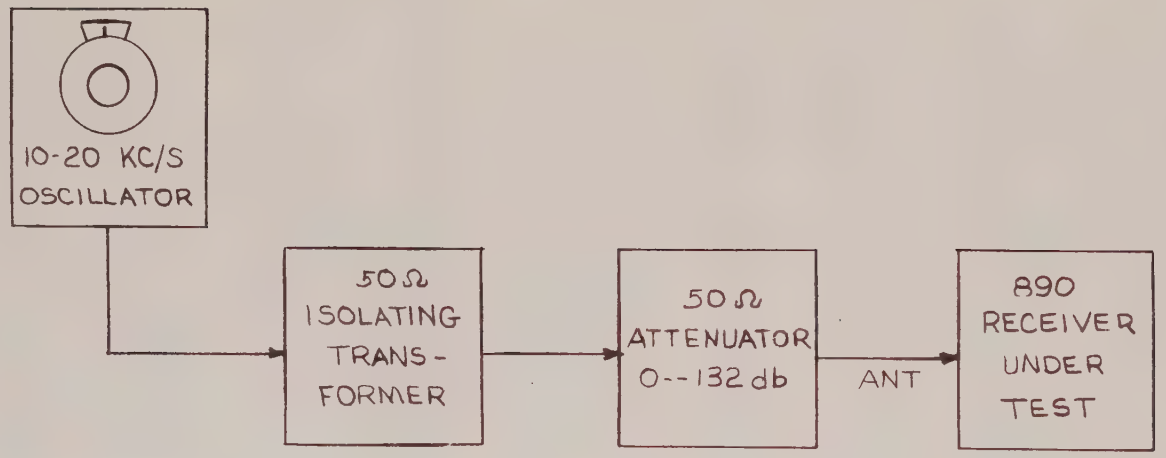
5. Adjustment for Rejection of Adjacent Channel Interference

a) Connect power and frequency standard voltages (if necessary) to the unit. Connect the test fixtures and equipment shown in figure 5-2 to the antenna.

b) Set receiver frequency to 20 kc/s, and set frequency of the audio oscillator to 15 kc/s ±2%. Adjust attenuator setting (high attenuation) so that the SERVO OFF lamp lights.

c) Decrease attenuation several db beyond point at which the SERVO OFF lamp is extinguished, then adjust C19 on PCB 62 so that the SERVO OFF once again lights. Again, decrease attenuation beyond lamp off point; then adjust C19 to light lamp again, if possible. (Note: Do not use a card extender. Perform this alignment with PCB 62 in its usual place. Use an insulated alignment tool. C19 is accessible through a hole in the right side of the chassis box.)

d) Repeat step (c) until further adjustment of C19 produces no decrease in minimum attenuation at which SERVO OFF will remain lighted.



OSCILLATOR: HP 200CD OR EQUAL
TRANSFORMER: TECHNITROL G3WA OR EQUAL
ATTENUATOR SET: HP 355 C&D OR EQUAL

Fig. 5-2: TEST FIXTURES AND EQUIPMENT FOR ADJUSTMENT FOR REJECTION OF ADJACENT CHANNEL INTERFERENCE

6. Adjustment of IF Gain

This adjustment (R59, PCB 62) is set at the factory to provide an operating threshold of approximately 60 mμv at 20 kc/s. Readjustment of this control is unnecessary in normal repair and alignment of the unit.

If desired, this control may be used to reduce the sensitivity of the receiver as appropriate in regions of high signal level, to increase effective noise threshold level. To do this, rotate the adjusting screw of R59 clockwise until the desired reduction of gain is accomplished, i.e., gain is at a minimum for which 24-hour continuous tracking is assured on both 20 kc/s and 60 kc/s.

7. Adjustment of Internal Standard Coarse Frequency (Model 892)

a) Connect power and antenna signal into the receiver unit. Switch POWER ON, and wait several hours (preferably one day) for thermal equilibrium. Switch FREQUENCY to receive a signal known to be on the air (check transmitter schedules for confirmation); confirm presence of signal by noting that the SERVO OFF lamp is off.

b) Remove the adjustment cover screw from the top of the frequency standard.

c) Set FINE FREQUENCY control to mid-range. (If the internal standard history shows a continuous frequency increase due to aging, it may be convenient to set FINE FREQUENCY high in its range.)

d) Unless the internal frequency is too far in error ($\epsilon >> 2 \times 10^{-7}$), the receiver will acquire and track automatically. Tracking is evidenced by return of the Δt trace to normal position when displaced 5 microseconds or so in either direction. In this case, simply adjust coarse frequency, using the Allen wrench

supplied with the unit, to bring internal frequency into agreement with radio signal frequency, as evidenced by a low slope Δt record.

e) In the event that the internal standard frequency is too far in error to permit tracking switch RECORDER to $\Phi\mu s$ and note the behavior of the recorder indicator. A cyclic variation in reading will appear, relatively fast and of small amplitude if the frequency error is great, or slow and larger if the error is initially small.

Using the Allen wrench supplied, adjust the coarse frequency control in the direction that reduces frequency error, as indicated by progressively lower frequency and increased peak-to-peak recorder deflection. When, finally, the frequency error is sufficiently small, tracking acquisition will occur, and step (d) may then be followed.

8. Adjustment of Oscillator Fine Tuning Range (Model 892)

a) Adjust coarse tuning of the Sulzer 1B oscillator as outlined in procedure 7 above.

b) Adjust R20 for +3.0 volts dc on pin T of P3.

c) Set R3, FREQUENCY, to 500. Adjust R19 and R3 (if necessary) for +7.0 volts dc on pin U of P3.

d) Using the Allen wrench, adjust the frequency of the oscillator to within $\pm$100 parts in 10^{10} of the reference standard, as indicated by a Δt trace obtained using WWVL or WWVB, or by comparing to a calibrated local standard.

e) Set R3 (dial) to 1000 (maximum clockwise position). Adjust R20 so that the 1B Oscillator is +500 parts in 10^{10} high with respect to the reference. +500 in 10^{10} is equivalent to a rate of change of Δt amounting to +30 μsec in 10 minutes.

f) Set R3 to 0 (maximum counter-clockwise position). Adjust R19 so that the 1B Oscillator is -500 parts in 10^{10} low with respect to the reference.

g) Repeat procedures 2 and 3 if improved accuracy is desired.

h) Other methods may be used for obtaining the results of steps (e) and (f). In particular, the use of a frequency difference meter and a second frequency standard offers increased rapidity and convenience in setting FINE FREQUENCY span. In any event, the object is to obtain a span of 1000 parts in 10^{10}, with alignment of R19 and R20 performed as indicated to assure maximum control linearity.

VI. REPLACEABLE PARTS

This chapter is composed of lists of replaceable parts for the Series 890 VLF Receivers, as follows:

A. Model 890 VLF/LF Receiver, Chassis (See Dwg. 74A)
B. Receiver-Detector, PCB 62 (See Dwg. 71)
C. Synthesizer-Servo, PCB 64A (See Dwg. 72A)
D. 1 Mc/s Option
    1. Chassis (See Dwg. 76A)
    2. 1 Mc/s Input, PCB 66 (See Dwg. 73)
E. Model 892 VLF/LF Receiver
    1. Chassis (See Dwg. 76A)
    2. 1 Mc/s IN, Freq. Adj., Reg., PCB 69 (See Dwg. 71)

For convenience in ordering replacement parts from local supply sources, the manufacturer's name (according to Federal Supply vendor code below) and part number are given. Components that show no vendor number meet mil specs and can be purchased from several manufacturers. When ordering parts from TRACOR, Inc., please refer to Chapter VIII, PARTS ORDERING INFORMATION.

Vendor List

00815	Northern Engineering Laboratories, Inc., Burlington, Wisconsin
01295	Texas Instruments, Inc., Semiconductor-Components Div., Dallas, Texas
02660	Amphenol-Borg Electronics Corp., Broadview, Chicago, Illinois
02735	RCA Semiconductor and Materials Div., Somerville, New Jersey
13812	Dialco Electric Corp., Brooklyn, New York
16407	Nytronics, Inc., Lexington, Kentucky
16741	Triad Transformer Corp., Huntington, Indiana
19397	TRACOR, Inc., Austin, Texas
24455	Miniature Lamp Dept., General Electric Co., Cleveland, Ohio
35009	IRC Resistor Division, Renfrew Electric Co., Ltd., Toronto, Ontario
56289	Sprague Electric Co., North Adams, Massachusetts

70001	Thermalloy Co., Dallas, Texas
70903	Belden Mfg. Co., Chicago, Illinois
71400	Bussman Mfg. Div., McGraw-Edison Co., St. Louis, Missouri
71590	Centralab Division of Globe-Union, Inc., Milwaukee, Wisconsin
71785	Cinch Mfg. Co., Div. of United-Carr Fastener Corp., Chicago, Illinois
72982	Erie Resistor Corp., Erie, Pennsylvania
73293	Hughes Products Div. of Hughes Aircraft Co., Newport Beach, California
80294	Bourns Laboratories Inc., Riverside, California
80583	Hammarlund Co., Inc., New York, New York
84171	Arco Electronics, Inc., Great Neck, New York
90095	Technitrol Engineering Co., Philadelphia, Pennsylvania
91506	Augat Brothers, Inc., Attleboro, Massachusetts
91929	Minneapolis-Honeywell Regulator Co., Micro Switch Division, Freeport, Illinois
93332	Sylvania Electric Products, Inc., Semiconductor Products Div., Woburn, Massachusetts
99800	Delevan Electronics Corp., East Aurora, New York

A. Model 890 VLF/LF Receiver, Chassis

Ref.	Value	Description	Vendor	Part No.
C3	1000 µf	Capacitor, aluminum elect. 25 vdcw	56289	TVL-1230
C4	10 µµf	Capacitor, dipped mica, 500 vdcw, ±5%	84171	DM-15-100J
C5	2.9-35 µµf	Capacitor, "Micro", variable	80583	MAPC-35
C6	180 µµf	Capacitor, dipped mica, 500 vdcw, ±5%		CM05F181J03
C7	4.5-100 µµf	Capacitor, variable	80583	MAPC-100
CR1		Diode	02735	1N3193
CR2		Diode	02735	1N3193
DS1		Lamp, 14v, .08 amp	24455	330
DS2		Lamp, 14v, .08 amp	24455	330
F1		Fuse, 1/2 amp., 1/4"x1 1/4"	71400	AGC-1/2
F2		Fuse, 1 amp., 1/4" x 1 1/4"	71400	AGC-1
J1		Socket, 22 pin, female	02660	143-022-01
J2		Socket, 22 pin, female	02660	143-022-01
J3		Socket, 22 pin, female	02660	143-022-01
J4		Socket, 22 pin, female	02660	143-022-01
J5		Socket, 6 pin, female, type AB for chassis mounting	71785	S-306
J6		Socket, 16 pin, female	02660	26-4401-16S
J7		Socket, BNC		UG-1094/u
J8		Socket, BNC		UG-1094/u
J9		Socket, BNC		UG-1094/u
M1		Recorder, strip chart	19397	93
P5		Plug, 6 pin, male, type CCT with cable clamp	71785	P-306
Q1		Transistor, PNP, Ge	01295	2N2552
R1	100	Resistor, carbon comp., 1/2w, ±10%		RC20GF101K
S1		Switch, 5 pole, 3 pos., rotary, wafer (modified)	19397	57
S2		Switch, DPDT, center OFF, 3 pos., momentary contact	91929	12TS115-7

A. Model 890 VLF/LF Receiver, Chassis

Ref.	Value	Description	Vendor	Part No.
S3		Switch, rotary, short shaft (modified)	19397	714
S4		Switch, rotary, short shaft (modified)	19397	714
T1		Transformer, filament, PR1: 115 vac Sec 12.6 volt 1.5 amp.	16741	F-25X
XDS1		Lamp socket, red dome	13812	162-8430-931
XDS2		Lamp socket, green dome	13812	162-8430-932
XF1		Fuseholder	71400	HKP
XF2		Fuseholder	71400	HKP
XY1		Socket, octal, w/mounting plate	02660	78RS8
XY2		Socket, crystal	91506	8000-AG2
Y1		Crystal unit, 100 kc/s	00815	T-9D
		Calibration tolerance: ±.002% at 30° C		
		Q min: 100,000		
		Load Capacitance: 225 μμf		
		Maximum Drift: ±1 ppm/°C, 25-35° C		
Y3		Crystal unit, 5 Mc/s, .002% @ 25° C	00815	NE-6A
		Stability: crystal element cut for minimum deviation over range 0°C-50°C		
		Resonance: parallel		
		Load capacitance: 32±0.5 μμf		
		Holder: HC-6/u		
		Cable, power, 3 cond. w/ground plug	70903	17048S
		Card Guide	70001	8828-3
		Knob (modified)	19397	56

B. Receiver-Detector, PCB 62

Ref.	Value	Description	Vendor	Part No.
C1	.0033µf	Capacitor, mylar film, 200 vdcw, ±10%	56289	192P33292
C2	56 µf	Capacitor, Ta, 6 vdcw, ±10%		CS13AB560K
C3	1µf	Capacitor, Ta, 35 vdcw, ±10%		CS13AF010K
C4	1µf	Capacitor, Ta, 35 vdcw, ±10%		CS13AF010K
C5	1µf	Capacitor, Ta, 35 vdcw, ±10%		CS13AF010K
C6	1800µµf	Capacitor, dipped mica, 500 vdcw, ±2%		CM06F182G03
C7	.0039µf	Capacitor, dipped mica, 500 vdcs, ±5%		CM06F392J03
C8	.0018µf	Capacitor, mylar film, 200 vdcw, ±10%	56289	192P18292
C9	0.1 µf	Capacitor, disc cer., 10 vdcw, +80% -20%	71590	UK-10-104
C10	0.1 µf	Capacitor, disc cer., 10 vdcw, +80% -20%	71590	UK-10-104
C11	100 µf	Capacitor, Ta, 10 vdcw, ±10%		CS13AC101K
C12	100 µf	Capacitor, Ta, 10 vdcw, ±10%		CS13AC101K
C13	.082 µf	Capacitor, mylar film, 200 vdcw, ±5%	56289	192P82392
C14	.082 µf	Capacitor, mylar film, 200 vdcw, ±5%	56289	192P82392
C15	47 µµf	Capacitor, dipped mica, 500 vdcw, ±5%		CM05F470J3
C16	120 µf	Capacitor, Ta, 10 vdcw, ±10%		CS13AC121K
C17	390 µµf	Capacitor, dipped mica, 500 vdcw, ±5%		CM05F391J03
C18	12 µµf	Capacitor, dipped mica, 500 vdcw, ±5%		CM05C120K03
C19	5-50 µf	Capacitor, cer. trim, 500 vdcw	72982	503-000-53R
C20	6.8 µf	Capacitor, Ta, 6 vdcw, ±10%		CS13AB6R8K
C21	0.1 µf	Capacitor, disc cer., 10 vdcw, +80% -20%	71590	UK-10-104
C22	6.8 µf	Capacitor, Ta, 6 vdcw, ±10%		CS13AB6R8K
C23	0.1 µf	Capacitor, disc cer., 10 vdcw, +80 -20%	71590	UK-10-104
C24	0.1 µf	Capacitor, disc cer., 10 vdcw, +80% -20%	71590	UK-10-104

B. Receiver-Detector, PCB 62

Ref.	Value	Description	Vendor	Part No.
C25	0.1 μf	Capacitor, disc cer., 10 vdcw, +80% -20%	71590	UK-10-104
C26	.0051 μf	Capacitor, dipped mica, 500 vdcw, ±5%	84171	DM-19-512J
C27	0.1 μf	Capacitor, disc cer., 10 vdcw, +80% -20%	71590	UK-10-104
C28	0.1 μf	Capacitor, disc cer., 10 vdcw, +80% -20%	71590	UK-10-104
C29	0.1 μf	Capacitor, disc cer., 10 vdcw, +80% -20%	71590	UK-10-104
C30	0.1 μf	Capacitor, disc cer., 10 vdcw, +80% -20%	71590	UK-10-104
C31	0.1 μf	Capacitor, disc cer., 10 vdcw, +80% -20%	71590	UK-10-104
C32	0.1 μf	Capacitor, disc cer., 10 vdcw, +80% -20%	71590	UK-10-104
C33	0.1 μf	Capacitor, disc cer., 10 vdcw, +80% -20%	71590	UK-10-104
C34	0.1 μf	Capacitor, disc cer., 10 vdcw, +80% -20%	71590	UK-10-104
C35	0.1 μf	Capacitor, disc cer., 10 vdcw, +80% -20%	71590	UK-10-104
C36	0.1 μf	Capacitor, disc cer., 10 vdcw, +80% -20%	71590	UK-10-104
C37	0.1 μf	Capacitor, disc cer., 10 vdcw, +80% -20%	71590	UK-10-104
L1	2.2 mh	Inductor, ±5%	99800	2500-44
L2	2.4 mh	Inductor, ±5%	99800	2500-46
L3	270 μh	Inductor, ±5%	99800	2500-00
L4	1.0 mh	Inductor, ±5%	99800	2500-28
L5	1.0 mh	Inductor, ±5%	99800	2500-28
L6	1.0 mh	Inductor, ±5%	99800	2500-28
P1		Plug, 22 pin, male	02660	133-022-03
Q1		Transistor, NPN, Ge	01295	2N1304
Q2		Transistor, PNP, Ge	01295	2N1305
Q3		Transistor, PNP, Ge	01295	2N1305

B. Receiver-Detector, PCB 62

Ref.	Value	Description	Vendor	Part No.
Q4		Transistor, PNP, Ge	01295	2N1305
Q5		Transistor, PNP, Ge	01295	2N1305
Q6		Transistor, NPN, Ge	01295	2N1304
Q7		Transistor, NPN, Ge	01295	2N1304
Q8		Transistor, NPN, Ge	01295	2N1304
Q9		Transistor, NPN, Ge	01295	2N1304
Q10		Transistor, NPN, Ge	01295	2N1304
Q11		Transistor, NPN, Ge	01295	2N1304
Q12		Transistor, NPN, Ge	01295	2N1304
Q13		Transistor, NPN, Ge	01295	2N1304
Q14		Transistor, NPN, Ge	01295	2N1304
Q15		Transistor, PNP, Ge	02735	2N1319
Q16		Transistor, PNP, Ge	01295	2N1305
Q17		Transistor, NPN, Si	02735	2N2270
Q18		Transistor, Ge	93332	2N711B
Q19		Transistor, NPN, Ge	01295	2N1304
Q20		Transistor, NPN, Ge	01295	2N1304
Q21		Transistor, NPN, Ge	01295	2N1304
Q22		Transistor, NPN, Ge	01295	2N1304
Q23		Transistor, NPN, Ge	01295	2N1304
Q24		Transistor, NPN, Ge	01295	2N1304
Q25		Transistor, NPN, Ge	01295	2N1304
Q26		Transistor, NPN, Ge	01295	2N1304
Q27		Transistor, NPN, Ge	01295	2N1304
Q28		Transistor, NPN, Ge	01295	2N1304
Q29		Transistor, NPN, Ge	01295	2N1304
Q30		Transistor, NPN, Ge	01295	2N1304
Q31		Transistor, NPN, Ge	01295	2N1304
Q32		Transistor, NPN, Ge	01295	2N1304
Q33		Transistor, NPN, Ge	01295	2N1304
Q34		Transistor, PNP, Ge	01295	2N1305

B. Receiver-Detector, PCB 62

Ref.	Value	Description	Vendor Part No.
R1	680k	Resistor, carbon comp., 1/4w, ±10%	RC07GF684K
R2	1.5k	Resistor, carbon comp., 1/4w, ±10%	RC07GF152K
R3	1k	Resistor, carbon comp., 1/4w, ±10%	RC07GF102K
R4	68	Resistor, carbon comp., 1/4w, ±10%	RC07GF680K
R5	1k	Resistor, carbon comp., 1/4w, ±10%	RC07GF102K
R6	4.7k	Resistor, carbon comp., 1/4w, ±10%	RC07GF472K
R7	680	Resistor, carbon comp., 1/4w, ±10%	RC07GF681K
R8	1k	Resistor, carbon comp., 1/4w, ±10%	RC07GF102K
R9	33k	Resistor, carbon comp., 1/4w, ±10%	RC07GF333K
R10	1.5k	Resistor, carbon comp., 1/4w, ±10%	RC07GF152K
R11	10k	Resistor, carbon comp., 1/4w, ±10%	RC07GF103K
R12	1.5k	Resistor, carbon comp., 1/4w, ±10%	RC07GF152K
R13	2.2k	Resistor, carbon comp., 1/4w, ±10%	RC07GF222K
R14	909	Resistor, carbon film, 1/2w, ±1%	RN65D9090F
R15	1.00k	Resistor, carbon film, 1/2w, ±1%	RN65D1001F
R16	1.47k	Resistor, carbon film, 1/2w, ±1%	RN65D1471F
R17	1.47k	Resistor, carbon film, 1/2w, ±1%	RN65D1471F
R18	82	Resistor, carbon comp., 1/4w, ±10%	RC07GF820K
R19	2.2k	Resistor, carbon comp., 1/4w, ±10%	RC07GF222K
R20	47	Resistor, carbon comp., 1/4w, ±10%	RC07GF470K
R21	5.62k	Resistor, carbon film, 1/2w, ±1%	RN65D5621F
R22	5.62k	Resistor, carbon film, 1/2w, ±1%	RN65D5621F
R23	2.2k	Resistor, carbon comp., 1/4w, ±10%	RC07GF222K
R24	2.2k	Resistor, carbon comp., 1/4w, ±10%	RC07GF222K
R25	1.1k	Resistor, carbon film, 1/2w, ±1%	RN65D1101F
R26	1.00k	Resistor, carbon film, 1/2w, ±1%	RN65D1001F
R27	10k	Resistor, carbon comp., 1/4w, ±10%	RC07GF103K
R28	10k	Resistor, carbon comp., 1/4w, ±10%	RC07GF103K
R29	1.5k	Resistor, carbon comp., 1/4w, ±10%	RC07GF152K
R30	34.8k	Resistor, carbon film, 1/2w, ±1%	RN65D34R8F
R31	34.8k	Resistor, carbon film, 1/2w, ±1%	RN65D34R8F

B. Receiver-Detector, PCB 62

Ref.	Value	Description	Vendor	Part No.
R32	1.1k	Resistor, carbon film, 1/2w, ±1%		RN65D1101F
R33	1.00k	Resistor, carbon film, 1/2w, ±1%		RN65D1001F
R34	562	Resistor, carbon film, 1/2w, ±1%		RN65D5620F
R35	560	Resistor, carbon comp., 1/4w, ±10%		RC07GF561K
R36	4.7k	Resistor, carbon comp., 1/4w, ±10%		RC07GF472K
R37	1.5k	Resistor, carbon comp., 1/4w, ±10%		RC07GF152K
R38	1.5k	Resistor, carbon comp., 1/4w, ±10%		RC07GF152K
R39	10k	Resistor, carbon comp., 1/4w, ±10%		RC07GF103K
R40	90.9k	Resistor, carbon film, 1/2w, ±1%		RN65D9092F
R41	5.11k	Resistor, carbon film, 1/2w, ±1%		RN65D5111F
R42	46.4k	Resistor, carbon film, 1/2w, ±1%		RN65D4642F
R43	1.00k	Resistor, carbon film, 1/2w, ±1%		RN65D1001F
R44	464	Resistor, carbon film, 1/2w, ±1%		RN65D4640F
R45	825	Resistor, carbon film, 1/2w, ±1%		RN65D8250F
R46	2.2k	Resistor, carbon comp., 1/4w, ±10%		RC07GF222K
R47	1k	Resistor, carbon comp., 1/4w, ±10%		RC07GF102K
R48	100	Resistor, carbon comp., 1/4w, ±10%		RC07GF101K
R49	100	Resistor, carbon comp., 1/4w, ±10%		RC07GF101K
R50	2.2k	Resistor, carbon comp., 1/4w, ±10%		RC07GF222K
R51	2.2k	Resistor, carbon comp., 1/4w, ±10%		RC07GF222K
R52	68	Resistor, carbon comp., 1/4w, ±10%		RC07GF680K
R53	2.2k	Resistor, carbon comp., 1/4w, ±10%		RC07GF222K
R54	1k	Resistor, carbon comp., 1/4w, ±10%		RC07GF102K
R55	2.2k	Resistor, carbon comp., 1/4w, ±10%		RC07GF222K
R56	2.2k	Resistor, carbon comp., 1/4w, ±10%		RC07GF222K
R57	2.2k	Resistor, carbon comp., 1/4w, ±10%		RC07GF222K
R58	82	Resistor, carbon comp., 1/4w, ±10%		RC07GF820K
R59	2k	Resistor, "E-Z" trimpot, 1/2w, ±10%	80294	3067P-1-202
R60	470	Resistor, carbon comp., 1/4w, ±10%		RC07GF471K

B. Receiver-Detector, PCB 62

Ref.	Value	Description	Vendor	Part No.
R61	2.2k	Resistor, carbon comp., 1/4w, ±10%		RC07GF222K
R62	2.2k	Resistor, carbon comp., 1/4w, ±10%		RC07GF222K
R63	68	Resistor, carbon comp., 1/4w, ±10%		RC07GF680K
R64	2.2k	Resistor, carbon comp., 1/4w, ±10%		RC07GF222K
R65	1k	Resistor, carbon comp., 1/4w, ±10%		RC07GF102K
R66	2.2k	Resistor, carbon comp., 1/4w, ±10%		RC07GF222K
R67	2.2k	Resistor, carbon comp., 1/4w, ±10%		RC07GF222K
R68	68	Resistor, carbon comp., 1/4w, ±10%		RC07GF680K
R69	2.2k	Resistor, carbon comp., 1/4w, ±10%		RC07GF222K
R70	1k	Resistor, carbon comp., 1/4w, ±10%		RC07GF102K
R71	330	Resistor, carbon comp., 1/4w, ±10%		RC07GF331K
R72	2.2k	Resistor, carbon comp., 1/4w, ±10%		RC07GF222K
R73	2.2k	Resistor, carbon comp., 1/4w, ±10%		RC07GF222K
R74	68	Resistor, carbon comp., 1/4w, ±10%		RC07GF680K
R75	2.2k	Resistor, carbon comp., 1/4w, ±10%		RC07GF222K
R76	3.9k	Resistor, carbon comp., 1/4w, ±10%		RC07GF392K
R77	1k	Resistor, carbon comp., 1/4w, ±10%		RC07GF102K
R78	2.2k	Resistor, carbon comp., 1/4w, ±10%		RC07GF222K
R79	2.2k	Resistor, carbon comp., 1/4w, ±10%		RC07GF222K
R80	68	Resistor, carbon comp., 1/4w, ±10%		RC07GF680K
R81	2.2k	Resistor, carbon comp., 1/4w, ±10%		RC07GF222K
R82	3.9k	Resistor, carbon comp., 1/4w, ±10%		RC07GF392K
R83	1k	Resistor, carbon comp., 1/4w, ±10%		RC07GF102K
R84	2.2k	Resistor, carbon comp., 1/4w, ±10%		RC07GF222K
R85	1k	Resistor, carbon comp., 1/4w, ±10%		RC07GF102K
R86	47	Resistor, carbon comp., 1/4w, ±10%		RC07GF470K
R87	1k	Resistor, carbon comp., 1/4w, ±10%		RC07GF102K
R88	3.9k	Resistor, carbon comp., 1/4w, ±10%		RC07GF392K
R89	470	Resistor, carbon comp., 1/4w, ±10%		RC07GF471K
R90	47k	Resistor, carbon comp., 1/4w, ±10%		RC07GF473K

B. Receiver-Detector, PCB 62

Ref.	Value	Description	Vendor	Part No.
R91	2.2k	Resistor, carbon comp., 1/4w, ±10%		RC07GF222K
R92	560	Resistor, carbon comp., 1/4w, ±10%		RC07GF561K
R93	22k	Resistor, carbon comp., 1/4w, ±10%		RC07GF223K
T1		Transformer, pulse	90095	AMB3WA

C. Synthesizer-Servo, PCB 64

Ref.	Value	Description	Vendor	Part No.
C1	10 uuf	Capacitor, molded mica, 500 vdcw, ±10%		CM15B100K03
C2	5100 uuf	Capacitor, dipped mica, 500 vdcw, ±5%	84171	DM-19-512J
C3	1000 uuf	Capacitor, dipped mica, 100 vdcw, ±2%	84171	DM-15-102G
C4	.1 uf	Capacitor, disc cer., 10 vdcw, +80% -20%	71590	UK-10-104
C5	1000 uuf	Capacitor, dipped mica, 100 vdcw, ±2%	84171	DM-15-102G
C6	.01 uf	Capacitor, disc cer., 50 vdcw, +80%, -20%	71590	CK-103
C7	.1 uf	Capacitor, disc cer., 10 vdcw, +80%, -20%	71590	UK-10-104
C8	220 uuf	Capacitor, dipped mica, 500 vdcw, ±5%		CM05F221J03
C9	1000 uuf	Capacitor, dipped mica, 100 vdcw, ±2%	84171	DM-15-102G
C10	1000 uuf	Capacitor, dipped mica, 100 vdcw, ±2%	84171	DM-15-102G
C11	100 uf	Capacitor, Ta, 10 vdcw, ±10%		CS13AC101K
C12	100 uf	Capacitor, Ta, 10 vdcw, ±10%		CS13AC101K
C13	39 uf	Capacitor, Ta, 10 vdcw, ±10%		CS13AC390K
C14	39 uf	Capacitor, Ta, 10 vdcw, ±10%		CS13AC390K
C15	150 uuf	Capacitor, dipped mica, 500 vdcw, ±5%		CM05F151J03
C16	220 uuf	Capacitor, dipped mica, 500 vdcw, ±5%		CM05F221J03
C17	560 uuf	Capacitor, dipped mica, 300 vdcw, ±5%	84171	DM-15-561G
C18	1000 uuf	Capacitor, dipped mica, 100 vdcw, ±2%	84171	DM-15-102G
C19	1000 uuf	Capacitor, dipped mica, 100 vdcw, ±2%	84171	DM-15-102G
C20	1000 uuf	Capacitor, dipped mica, 100 vdcw, ±2%	84171	DM-15-102G

C. Synthesizer-Servo, PCB 64

Ref.	Value	Description	Vendor	Part No.
C21	.1 uf	Capacitor, disc cer., 10 vdcw, +80%, -20%	71590	UK-10-104
C22	470 uuf	Capacitor, disc cer., 1000 vdcw, ±20%	71590	DD-471
C23	470 uuf	Capacitor, disc cer., 1000 vdcw, ±20%	71590	DD-471
C24	.01 uf	Capacitor, disc cer., 50 vdcw, +80%, -20%	71590	CK-103
C25	.01 uf	Capacitor, disc cer., 50 vdcw, +80%, -20%	71590	CK-103
C26	1000 uuf	Capacitor, polystyrene, 100 vdcw, ±1%	84171	PE-102F
C27	22 uuf	Capacitor, dipped mica, 500 vdcw, ±5%		CM05E220J03
C28	22 uuf	Capacitor, dipped mica, 500 vdcw, ±5%		CM05E220J03
C29	150 uuf	Capacitor, dipped mica, 500 vdcw, ±5%		CM05F151J03
CR1		Diode, Ge	73293	1N96A
CR2		Diode, Ge	73293	1N96A
CR3		Diode, Ge	73293	1N96A
L1	1.0 mh	Inductor, ±5%	99800	2500-28
L2	10 mh	Inductor, ±5%	99800	2500-76
L3	4.7 uh	Inductor, variable	16407	V1V-4.70
L4	100 uh	Inductor, ±5%	99800	1537-76
L5	100 uh	Inductor, ±5%	99800	1537-76
L6	2.2 mh	Inductor, ±5%	99800	2500-44
L7	2.2 mh	Inductor, ±5%	99800	2500-44
L8	3.3 uh	Inductor, ±10%	99800	1537-24
L9	3.3 uh	Inductor, ±10%	99800	1537-24
L10	6.8 uh	Inductor, ±10%	99800	1537-32
L11	33 uh	Inductor, ±5%	99800	1537-52
L12	100 uh	Inductor, ±5%	99800	1537-76
L13	100 uh	Inductor, ±5%	99800	1537-76
L14	2.4 mh	Inductor, ±5%	99800	2500-46

C. Synthesizer-Servo, PCB 64A

Ref.	Value	Description	Vendor	Part No.
L15	820 µh	Inductor, ±5%	99800	2500-24
L16	2.2 mh	Inductor, ±5%	99800	2500-44
P2		Plug, 22 pin, male	02660	133-022-03
Q1		Transistor, NPN, Ge	01295	2N1304
Q2		Transistor, NPN, Ge	01295	2N1304
Q3		Transistor, NPN, Ge	01295	2N1304
Q4		Transistor, NPN, Ge	01295	2N1304
Q5		Transistor, PNP, Ge	93332	2N711B
Q6		Transistor, PNP, Ge	93332	2N711B
Q7		Transistor, PNP, Ge	01295	2N1305
Q8		Transistor, PNP, Ge	01295	2N1305
Q9		Transistor, NPN, Si	02735	2N2270
Q10		Transistor, PNP, Ge	01295	2N1305
Q11		Transistor, NPN, Si	02735	2N2270
Q12		Transistor, NPN, Ge	01295	2N1304
Q13		Transistor, PNP, Ge	01295	2N1305
Q14		Transistor, NPN, Ge	01295	2N1304
Q15		Transistor, PNP, Ge	01295	2N1305
Q16		Transistor, NPN, Si	02735	2N2270
Q17		Transistor, NPN, Si	02735	2N2270
Q18		Transistor, PNP, Ge	01295	2N1305
Q19		Transistor, NPN, Si	02735	2N2270
Q20		Transistor, PNP, Ge	01295	2N1305
Q21		Transistor, PNP, Ge	93332	2N711B
Q22		Transistor, PNP, Ge	93332	2N711B
Q23		Transistor, PNP, Ge	93332	2N711B
Q24		Transistor, PNP, Ge	93332	2N711B
Q25		Transistor, NPN, Si	02735	2N2270
Q26		Transistor, PNP, Ge	01295	2N1305
Q27		Transistor, NPN, Si	02735	2N2270
Q28		Transistor, PNP, Ge	01295	2N1305
Q29		Transistor, PNP, Ge	01295	2N1305

C. Synthesizer-Servo, PCB 64

Ref.	Value	Description	Vendor	Part No.
Q30		Transistor, NPN, Si	02735	2N2270
Q31		Transistor, PNP, Ge	01295	2N1305
Q32		Transistor, PNP, Ge	01295	2N1305
Q33		Transistor, NPN, Si	02735	2N2270
Q34		Transistor, NPN, Ge	01295	2N1304
Q35		Transistor, NPN, Ge	01295	2N1304
Q36		Transistor, NPN, Ge	01295	2N1304
Q37		Transistor, PNP, Ge	01295	2N1305
Q38		Transistor, NPN, Ge	01295	2N1304
Q39		Transistor, NPN, Ge	01295	2N1304
Q40		Transistor, PNP, Ge	01295	2N1305
Q41		Transistor, PNP, Ge	93332	2N711B
Q42		Transistor, PNP, Ge	93332	2N711B
R1	1 k	Resistor, carbon comp., 1/4w, ±10%		RC07GF102K
R2	330	Resistor, carbon comp., 1/4w, ±10%		RC07GF331K
R3	1.5 k	Resistor, carbon comp., 1/4w, ±10%		RC07GF152K
R4	1.5 k	Resistor, carbon comp., 1/4w, ±10%		RC07GF152K
R5	33	Resistor, carbon comp., 1/4w, ±10%		RC07GF330K
R6	3.3 k	Resistor, carbon comp., 1/4w, ±10%		RC07GF332K
R7	1.1 k	Resistor, carbon film, 1/2w, ±1%		RN65D1101F
R8	10 k	Resistor, carbon comp., 1/4w, ±10%		RC07GF103K
R9	33	Resistor, carbon comp., 1/4w, ±10%		RC07GF330K
R10	1.1 k	Resistor, carbon film, 1/2w, ±1%		RN65D1101F
R11	10 k	Resistor, carbon comp., 1/4w, ±10%		RC07GF103K
R12	3.3 k	Resistor, carbon comp., 1/4w, ±10%		RC07GF332K
R13	1 k	Resistor, carbon comp., 1/4w, ±10%		RC07GF102K
R14	220	Resistor, carbon comp., 1/4w, ±10%		RC07GF221K
R15	464	Resistor, carbon film, 1/2w, ±1%		RN65D4640F
R16	287	Resistor, carbon film, 1/2w, ±1%		RN65D2870F
R17	1.2 k	Resistor, carbon comp., 1/4w, ±10%		RC07GF122K
R18	1.1 k	Resistor, carbon film, 1/2w, ±1%		RN65D1101F
R19	1.1 k	Resistor, carbon film, 1/2w, ±1%		RN65D1101F

C. Synthesizer-Servo, PCB 64

Ref.	Value	Description	Vendor	Part No.
R20	560	Resistor, carbon comp., 1/4w, ±10%		RC07GF561K
R21	1.96 k	Resistor, carbon film, 1/2w, ±1%		RN65D1961F
R22	1.1 k	Resistor, carbon film, 1/2w, ±1%		RN65D1101F
R23	34.8 k	Resistor, carbon film, 1/2w, ±1%		RN65D3482F
R24	1.62 k	Resistor, carbon film, 1/2w, ±1%		RN65D1621F
R25	1 k	Resistor, carbon comp., 1/4w, ±10%		RC07GF102K
R26	220	Resistor, carbon comp., 1/4w, ±10%		RC07GF221K
R27	820	Resistor, carbon, comp., 1/4w, ±1%		RC07GF821K
R28	1.62 k	Resistor, carbon film, 1/2w, ±1%		RN65D1621F
R29	1.1 k	Resistor, carbon film, 1/2w, ±1%		RN65D1101F
R30	34.8 k	Resistor, carbon film, 1/2w, ±1%		RN65D3482F
R31	22	Resistor, carbon comp., 1/4w, ±10%		RC07GF220K
R32	270	Resistor, carbon comp., 1/4w, ±10%		RC07GF271K
R33	1 k	Resistor, carbon comp., 1/4w, ±10%		RC07GF102K
R34	909	Resistor, carbon film, 1/2w, ±1%		RN65D9090F
R35	909	Resistor, carbon film, 1/2w, ±1%		RN65D9090F
R36	237	Resistor, carbon film, 1/2w, ±1%		RN65D2370F
R37	10	Resistor, carbon comp., 1/4w, ±10%		RC07GF100K
R38	28.0 k	Resistor, carbon film, 1/2w, ±1%		RN65D2802F
R39	237	Resistor, carbon film, 1/2w, ±1%		RN65D2370F
R40	680	Resistor, carbon comp., 1/4w, ±10%		RC07GF681K
R41	680	Resistor, carbon comp., 1/4w, ±10%		RC07GF681K
R42	10 k	Resistor, carbon comp., 1/4w, ±10%		RC07GF100K
R43	147.0 k	Resistor, carbon film, 1/2w, ±1%		RN65D1473F
R44	680	Resistor, carbon comp., 1/4w, ±10%		RC07GF681K
R45	220	Resistor, carbon comp., 1/4w, ±10%		RC07GF221K
R46	680	Resistor, carbon comp., 1/4w, ±10%		RC07GF681K
R47	2.2 k	Resistor, carbon comp., 1/4w, ±10%		RC07GF222K
R48	4.7 k	Resistor, carbon comp., 1/4w, ±10%		RC07GF472K
R49	6.8 k	Resistor, carbon comp., 1/4w, ±10%		RC07GF682K
R50	1.2 k	Resistor, carbon comp., 1/4w, ±10%		RC07GF122K
R51	1.2 k	Resistor, carbon comp., 1/4w, ±10%		RC07GF122K

C. Synthesizer-Servo, PCB 64

Ref.	Value	Description	Vendor	Part No.
R52	330	Resistor, carbon comp., 1/4w, ±10%		RC07GF331K
R53	4.7 k	Resistor, carbon comp., 1/4w, ±10%		RC07GF472K
R54	6.8 k	Resistor, carbon comp., 1/4w, ±10%		RC07GF682K
R55	1 k	Resistor, "E-Z" trimpot	80294	3067P-1-102
R56	470	Resistor, carbon comp., 1/4w, ±10%		RC07GF471K
R57	909	Resistor, carbon film, 1/2w, ±1%		RN65D9090F
R58	237	Resistor, carbon film, 1/2w, ±1%		RN65D2370F
R59	909	Resistor, carbon film, 1/2w, ±1%		RN65D9090F
R60	1.47 k	Resistor, carbon film, 1/2w, ±1%		RN65D1471F
R61	237	Resistor, carbon film, 1/2w, ±1%		RN65D2370F
R62	909	Resistor, carbon film, 1/2w, ±1%		RN65D9090F
R63	6.98 k	Resistor, carbon film, 1/2w, ±1%		RN65D6981F
R64	100	Resistor, carbon comp., 1/4w, ±10%		RC07GF101K
R65	22	Resistor, carbon comp., 1/4w, ±10%		RC07GF220K
R66	680	Resistor, carbon comp., 1/4w, ±10%		RC07GF681K
R67	330	Resistor, carbon comp., 1/4w, ±10%		RC07GF331K
R68	330	Resistor, carbon comp., 1/4w, ±10%		RC07GF331K
R69	330	Resistor, carbon comp., 1/4w, ±10%		RC07GF331K
R70	330	Resistor, carbon comp., 1/4w, ±10%		RC07GF331K
R71	1.5 k	Resistor, carbon comp., 1/4w, ±10%		RC07GF152K
R72	56.2 k	Resistor, carbon film, 1/2w, ±1%		RN65D5622F
R73	237	Resistor, carbon film, 1/2w, ±1%		RN65D2370F
R74	909	Resistor, carbon film, 1/2w, ±1%		RN65D9090F
R75	1.5 k	Resistor, carbon comp., 1/4w, ±10%		RC07GF152K
R76	35.7 k	Resistor, carbon film, 1/2w, ±1%		RN65D3572F
R77	680	Resistor, carbon comp., 1/4w, ±10%		RC07GF681K
R78	22	Resistor, carbon comp., 1/4w, ±10%		RC07GF220K
R79	680	Resistor, carbon comp., 1/4w, ±10%		RC07GF681K
R80	237	Resistor, carbon film, 1/2w, ±1%		RN65D2370F
R81	147.0 k	Resistor, carbon film, 1/2w, ±1%		RN65D1473F
R82	680	Resistor, carbon comp., 1/4w, ±10%		RC07GF681K
R83	680	Resistor, carbon comp., 1/4w, ±10%		RC07GF681K

C. Synthesizer-Servo, PCB 64

Ref.	Value	Description	Vendor	Part No.
R84	50 k	Resistor, "E-Z", trimpot	80294	3068P-1-503
R85	68.1 k	Resistor, carbon film, 1/2w, ±1%		RN65D6812F
R86	10 k	Resistor, carbon comp., 1/4w, ±10%		RC07GF103K
R87	10 k	Resistor, carbon comp., 1/4w, ±10%		RC07GF103K
R88	10 k	Resistor, carbon comp., 1/4w, ±10%		RC07GF103K
R89	68	Resistor, carbon comp., 1/4w, ±10%		RC07GF680K
R90	330	Resistor, carbon comp., 1/4w, ±10%		RC07GF331K
R91	909	Resistor, carbon film, 1/2w, ±1%		RN65D9090F
R92	909	Resistor, carbon film, 1/2w, ±1%		RN65D9090F
R93	4.7 k	Resistor, carbon comp., 1/4w, ±10%		RC07GF472K
VR1		Diode, zener	01295	1N752A

D. 1 Mc/s Option

1. Chassis

Ref.	Value	Description	Vendor	Part No.
C1	2.9-35 μμf	Capacitor, "micro" variable	80583	MAPC-35
C2	10 μμf	Capacitor, dipped mica, 500 vdcw, ±5%	84171	DM-15-100J
XY2		Socket, crystal	91506	8000-AG2
Y2		Crystal unit, 1000 kc/s ±.002% @25°C Stability: crystal element cut for minimum deviation over range 0°C - 50°C Resonance: parallel Load capacitance: 32 ±0.5 μμf Holder: HC-6/U		NE-6A

D. 1 Mc/s Option

2. 1 Mc/s Input, PCB 66

Ref.	Value	Description	Vendor	Part No.
C1	150 uuf	Capacitor, dipped mica, 500 vdcw, ±5%		CM05F151J03
C2	680 μμf	Capacitor, dipped mica, 500 vdcw, ±5%	84171	DM-15-681J
C3	1000 μμf	Capacitor, dipped mica, 100 vdcw, ±2%	84171	DM-15-102G
C4	470 uuf	Capacitor, disc cer., 1000 vdcw, ±20%	71590	DD-471
C5	470 uuf	Capacitor, disc cer., 1000 vdcw, ±20%	71590	DD-471
C6	1000 uuf	Capacitor, dipped mica, 100 vdcw, ±2%	84171	DM-15-102G
C7	.01 uf	Capacitor, disc cer., 50 vdcw, +80%, -20%	71590	CK-103
C8	.01 uf	Capacitor, disc cer., 50 vdcw, +80%, -20%	71590	CK-103
C10	39 uf	Capacitor, Ta, 10 vdcw, ±10%		CS13AC390K
C11	39 uf	Capacitor, Ta, 10 vdcw, ±10%		CS13AC390K
CR1		Diode	73293	1N96A
L1	100 uh	Inductor, ±5%	99800	1537-76
L2	33 μh	Inductor, ±5%	99800	1537-52
P3		Plug, 22 pin, male	02660	133-022-03
Q1		Transistor, NPN, Ge	01295	2N1304
Q2		Transistor, NPN, Ge	01295	2N1304
Q3		Transistor, PNP, Ge	93332	2N711B
Q4		Transistor, PNP, Ge	01295	2N711B
Q5		Transistor, NPN, Si	02735	2N2270
Q6		Transistor, PNP, Ge	01295	2N1305
Q7		Transistor, NPN, Ge	01295	2N1304
Q8		Transistor, NPN, Ge	01295	2N1304
Q9		Transistor, NPN, Ge	01295	2N1304
R1	2.2 k	Resistor, carbon comp., 1/4w, ±10%		RC07GF222K
R2	1.8 k	Resistor, carbon comp., 1/4w, ±10%		RC07GF182K

D.2 1 Mc/s Input, PCB 66

Ref.	Value	Description	Vendor	Part No.
R3	470	Resistor, carbon comp., 1/4w, ±10%		RC07GF471K
R4	909	Resistor, carbon film, 1/2w, ±1%		RN65D9090F
R5	237	Resistor, carbon film, 1/2w, ±1%		RN65D2370F
R6	680	Resistor, carbon comp., 1/4w, ±10%		RC07GF681K
R7	6.98 k	Resistor, carbon film, 1/2w, ±1%		RN65D6981F
R8	22	Resistor, carbon comp., 1/4w, ±10%		RC07GF220K
R9	100	Resistor, carbon comp., 1/4w, ±10%		RC07GF101K
R10	330	Resistor, carbon comp., 1/4w, ±10%		RC07GF331K
R11	1.2 k	Resistor, carbon comp., 1/4w, ±10%		RC07GF122K
R12	1.2 k	Resistor, carbon comp., 1/4w, ±10%		RC07GF122K
R13	6.8 k	Resistor, carbon comp., 1/4w, ±10%		RC07GF682K
R14	6.8 k	Resistor, carbon comp., 1/4w, ±10%		RC07GF682K
R15	2.2 k	Resistor, carbon comp., 1/4w, ±10%		RC07GF222K
R16	100	Resistor, carbon comp., 1/4w, +10%		RC07GF101K
R17	1.5 k	Resistor, carbon comp., 1/4w, ±10%		RC07GF152K
R24	4.7 k	Resistor, carbon comp., 1/4w, ±10%		RC07GF472K
R25	4.7 k	Resistor, carbon comp., 1/4w, ±10%		RC07GF472K

E. Model 892 VLF/LF Receiver

1. Chassis

The following replaceable parts are added to the Model 890 Chassis to make the Model 892 Chassis.

Ref.	Value	Description	Vendor	Part No.
C1	10 uuf	Capacitor, dipped mica, 500 vdcw, ±5%	84171	DM-15-100J
C2	2.9-35 uuf	Capacitor, "micro", variable	80583	MAPC-35
C8	1000 uf	Capacitor, aluminum elect., 25 vdcw	56289	TVL-1230
CR3		Diode	02735	1N3193
CR4		Diode	02735	1N3193
F3		Fuse, 1/4" x 1-1/4", 1/2 amp	71400	AGC-1/2
J10		Socket, BNC		UG-1094/U
J11		Socket, BNC		UG-1094/U
J12		Socket, BNC		UG-1094/U
J13		Socket, BNC		UG-1094/U
Q2		Transistor, PNP, Ge	01295	2N2552
R2	100	Resistor, carbon comp., 1/2w, ±10%		RC20GF101K
R3	20 k	Resistor, 10 turn, wirewound potentiometer	80294	3500S-2-203
R4	15	Resistor, carbon comp., 1/2w, ±10%		RC20GF150K
S5		Switch, SPDT, toggle	91929	11TS115-7
XF3		Fuseholder	71400	HKP
XY4		Socket, octal	71785	8EB
Y2		Crystal unit, 100 kc/s, .002% @25°C Stability: crystal element cut for minimum deviation over range 0°C - 50°C Resonance: parallel Load capacitance: 32 ±0.5 μμf Holder: HC-6/U	00815	NE-6A
Y4		Oscillator, 1.0 Mc/s output Capable of operating at 21.0 vdc	19397	Sulzer 1B
		Dial, 10 turn counting, 1" dia. "Revodex"	35009	RD-462

E. Model 892 VLF/LF Receiver

2. 1 Mc/s IN, Freq. Adj., Reg., PCB 69

Ref.	Value	Description	Vendor	Part No.
C9	10 μf	Capacitor, Ta, 35 vdcw, ±10%		CS13AF100K
Q10	39 μf	Capacitor, Ta, 10 vdcw, ±10%		CS13AC390K
Q11	39 μf	Capacitor, Ta, 10 vdcw, ±10%		CS13AC390K
R18	28.7 k	Resistor, metal film, 1/8w, ±1%		RN60C2872F
R19	20.0 k	Resistor, "E-Z", trimpot	80294	3067P-1-203
R20	20.0 k	Resistor, "E-Z", trimpot	80294	3067P-1-203
R21	1.33 k	Resistor, carbon film, 1/2w, ±1%		RN65D1331F
R22	909	Resistor, carbon film, 1/2w, ±1%		RN65D9090F
R23	1.5 k	Resistor, carbon comp., 1/4w, ±10%		RC07GF152K

VII. PARTS ORDERING INFORMATION

To order a replacement part, address order either to your authorized TRACOR, Inc. sales representative or to:

Customer Service
TRACOR, Inc.
6500 Tracor Lane
Austin, Texas 78721

Specify the following information for each part:

(a) Model and serial number of the instrument from the back panel.

(b) Assembly or sub-assembly, from the part itself or from the heading of the pertinent section of the list of replaceable parts.

(c) Circuit reference designator and full description of the part as shown in the list of replaceable parts.

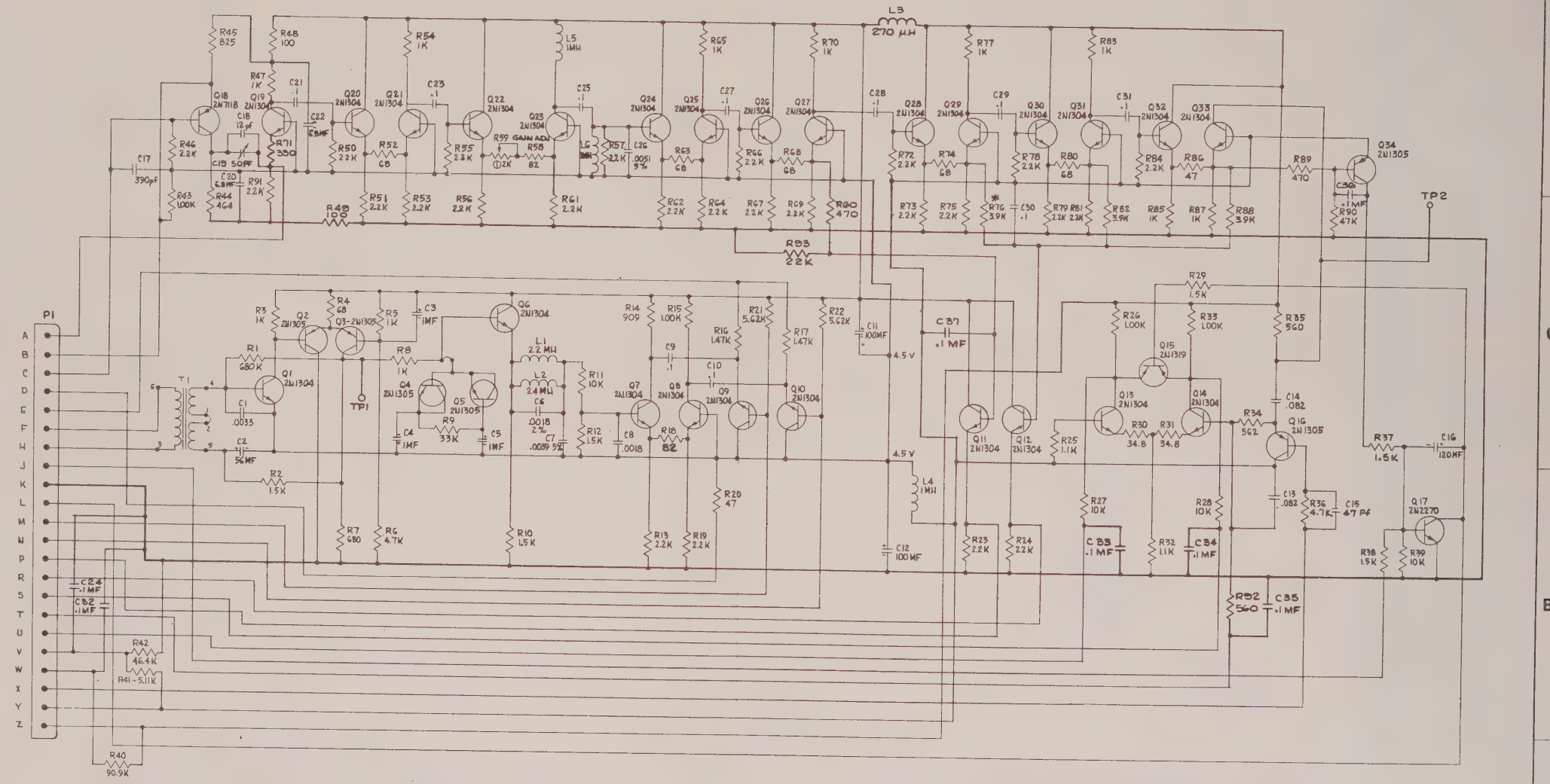
To order a replacement for a part not listed in the previous chapter, add as complete a description as possible of its function and location.

Part numbers as shown in the previous chapter will change occasionally as vendor items are re-evaluated or as improved components become available. The equivalent component used in current production at the time orders are received will be shipped.

VIII. SCHEMATIC DIAGRAMS

Dwg. No.	Title
71	Receiver-Detector, PCB 62
72A	Synthesizer-Servo, PCB 64A
73	Frequency Divider, PCB 69
74A	890 Chassis
76A	892 Chassis

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	X1	RELEASED	10-9-64	ADD



A	CRYSTAL I.F. FILTER OUTPUT IN
B	CRYSTAL I.F. FILTER INPUT OUT
C	MIXER I.F./CALIBRATE IN
D	CALIBRATE I.F. LOAD LINE
E	MIXER OUT
F	ANTENNA IN
H	ANTENNA COMMON
J	SERVO DISABLE LINE
K	GROUND
L	SERVO OFF LAMP OUT
M	80/160 KC LO" L.O. IN
N	80/160 KC L180° L.O. IN
P	CARRIER LEVEL REF OUT (-)
R	CARRIER LEVEL OUT (+)
S	ADVANCE ΔT SERVO OUT
T	φ OUT (+)
U	RETARD ΔT SERVO OUT
V	φ OUT (-)
W	φ BIAS COMP
X	SYNC DET COH. 100KC IN
Y	REGULATED +4.5 V BIAS IN
Z	REGULATED +9V POWER IN

* NOTE: R76 NORMALLY OMITTED

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
DO NOT SCALE DRAWINGS
TOLERANCES
DECIMALS | FRACTIONS | ANGLES
MATERIAL

ENGINEER	C. SLover	10/5/64
CHECKED		
DRAFTSMAN	PERRY	5-11-64

TRACOR, INC. AUSTIN, TEXAS

SCHEMATIC,
RECEIVER-DETECTOR,
PCB G2

SIZE	CODE IDENT NO		
4	7056	71	X1

SCALE — SHEET OF

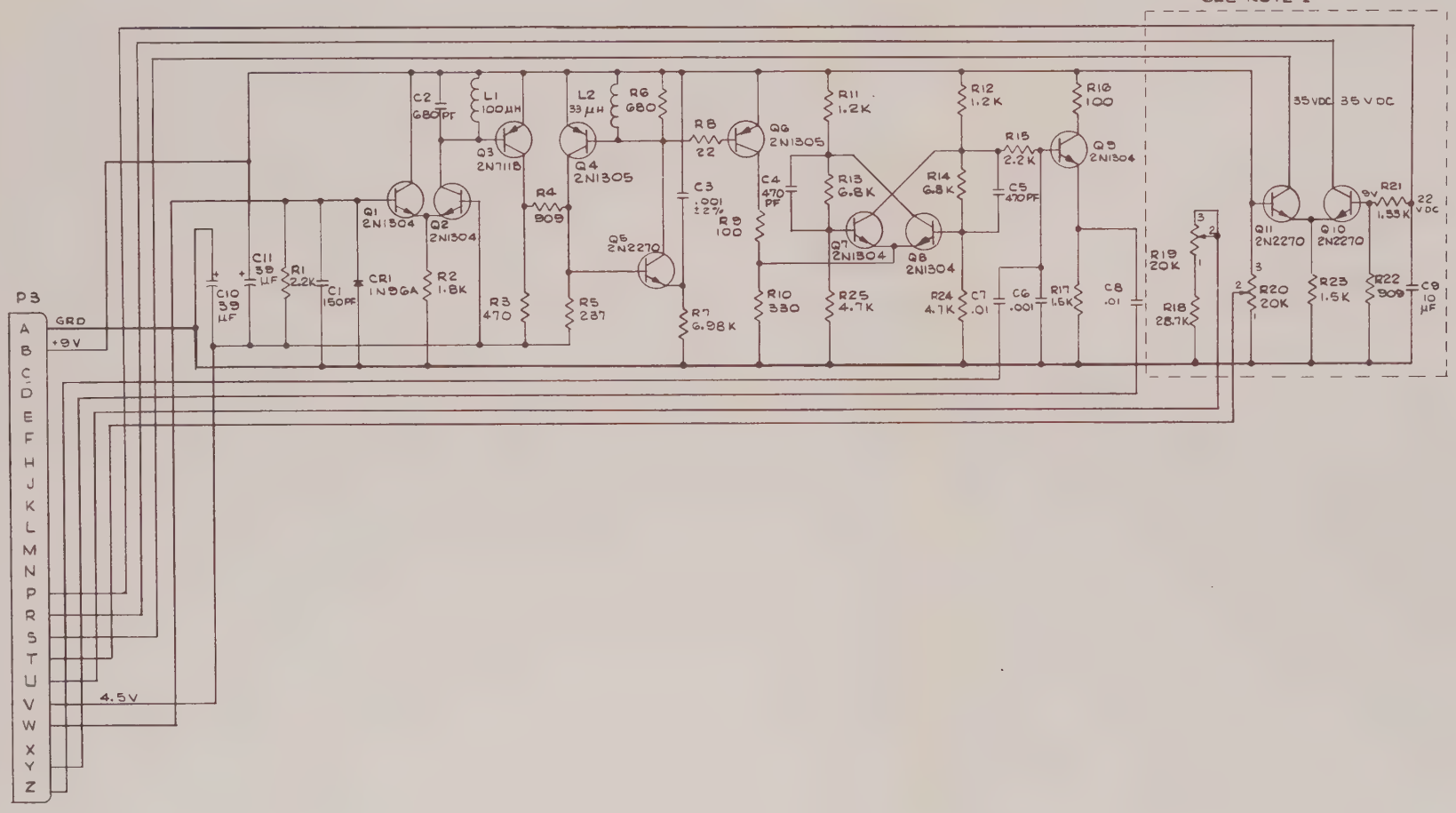
PCB 890-2 SYNTHESIZER SERVO

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	X	RELEASED	10-9-64	ADO
	A	ECO 1261: L16 WAS 2.4mH, L15 WAS 820μH, C26 WAS .001Z	11-9-64	ADO

A - GROUND
B - REGULATED +9V SUPPLY IN
C - ADVANCE AT SERVO INPUT
D - RETARD AT SERVO INPUT
E - UNREGULATED POWER IN
F - REGULATOR CONTROL OUT
H - 3 CALIBRATE OUT 100 KC
J - REGULATED +4.5V BIAS OUT
K - COHERENT 5 MC OUT
L - COHERENT 100 KC OUT
M - STANDARD 10K PPS OUT
N - AT RECORD BIAS OUT
P - 80/160 KC ∠0° L.O. OUT
R - 80/160 KC ∠180° L.O. OUT
S - 80/160 KC L.O. TUNING LINE
T - EXTERNAL 100μs RECORD OUT
U - INTERNAL 100μs RECORD OUT
V - S.D. COHERENT 100KC OUT
W - N.C.
X - STANDARD 100KC IN
Y - COHERENT 5MC IN
Z - COHERENT 10K PPS OUT

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. DO NOT SCALE DRAWINGS			TRACOR, INC. AUSTIN, TEXAS
TOLERANCES			SCHEMATIC SYNTHESIZER-SERVO, PCB 64A
DECIMALS	FRACTIONS	ANGLES	
MATERIAL			ENGINEER C SLOVER 10/5/64; CHECKED; DRAFTSMAN BOLING 5/8/64
NEXT ASSY	USED ON		SIZE 4; CODE IDENT NO 7056; 72; A
APPLICATION			SCALE NONE; SHEET 1 OF 1

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	X,	RELEASED	10-9-64	ABD

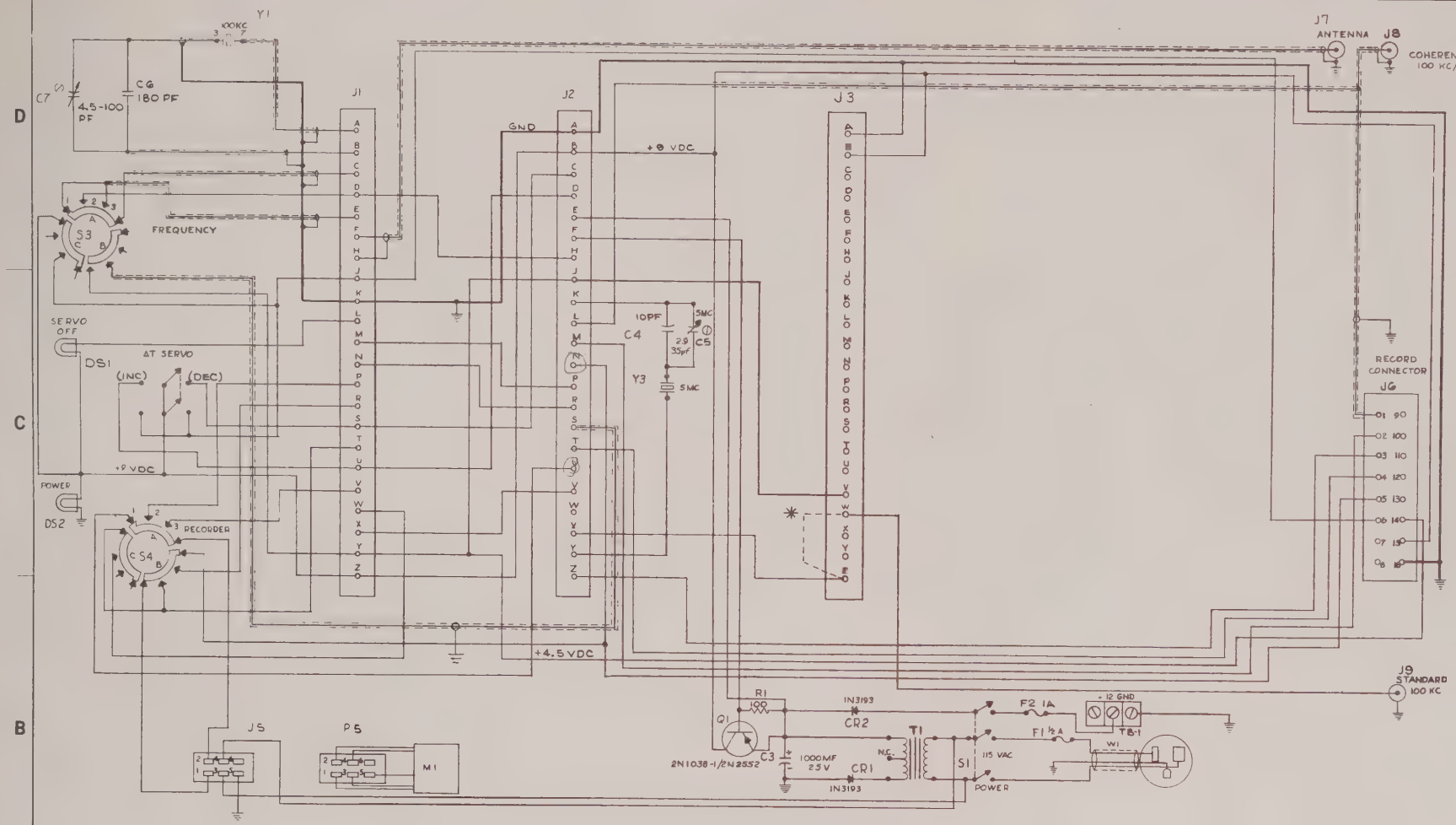


NOTE
1. CIRCUITRY INSIDE THE DASHED LINE BOX IS NOT INCLUDED ON PRINTED CIRCUIT ASSEMBLY, 1 MC/S INPUT G6; PRINTED CIRCUIT ASSEMBLY, TIME SIGNAL G7; AND PRINTED CIRCUIT ASSEMBLY, TIME SIGNAL & 1 MC/S INPUT G8.

A- GROUND
B- REGULATED + 9VDC SUPPLY
C-
D-
E-
F-
H-
J-
K-
L-
M-
N-
P- REGULATED +22 VDC IN
R- UNREGULATED +35 VDC IN
S- REGULATOR CONTROL OUT
T- FINE FREQ CALIBRATE OUT
U- FINE FREQ ADJ OUT
V- REGULATED +4.5 VDC BIAS IN
W- 1.0 MC/S IN
X- NC
Y- 100 KC/S' OUT
Z- 100 KC/S' OUT

		UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES DO NOT SCALE DRAWINGS		TRACOR, INC. AUSTIN, TEXAS
		TOLERANCES		SCHEMATIC, FREQUENCY DIVIDER TIME SIGNAL, PCB 69
		DECIMALS / FRACTIONS / ANGLES	ENGINEER C. S LOMER 10-8-64	
		MATERIAL	CHECKED	
NEXT ASSY	USED ON		DRAFTSMAN CONTRERAS	SIZE 4 / CODE IDENT NO 7056 / 73 / X1
APPLICATION				SCALE NONE / SHEET OF

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	X	RELEASED	10-9-64	RDD
	A	ECO 159	11-23-64	RDD



RECORD CONNECTOR

1. COHERENT 100 KC/S	9.
2. STANDARD 10 KC/S	10
3. COHERENT 10 KC/S	11
4. ΔT RECORD	12
5. ΔT RECORD REF.	13.
6. SERVO DISABLE	14. +4.5 BIAS
7.	15. +9V POWER
8.	16. GROUND

FREQUENCY (S3)
1. 20 KC/S
2. CAL
3. 60 KC/S

RECORDER (S4)
1. ΔT
2. db
3. Φ

* NOTE: JUMPER BETWEEN W & Z ON J3 IS REMOVED WHEN THE PRINTED CIRCUIT ASSEMBLY, 1 MC/S INPUT (OPTION) GG IS USED.

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES DO NOT SCALE DRAWINGS

TOLERANCES: DECIMALS | FRACTIONS | ANGLES

MATERIAL.

ENGINEER	C. Slover	10/5/64
CHECKED		
DRAFTSMAN	L. HARDEN	5/21/64

TRACOR, INC. AUSTIN, TEXAS

890 CHASSIS
SCHEMATIC

SIZE	CODE IDENT NO.		
4	7056	74	A

SCALE | SHEET OF

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	X1	RELEASED	10-7-64	ADD
	A	ECO 1160	12-23-64	ADD

Y1 100 KC

C7 4.5-100 PF

C6 180 PF

S3 FREQUENCY

SERVO OFF

DS1 AT SERVO (INC) (DEC)

+9 VDC

POWER

DS2 RECORDER

S4

J1

J2

GRD

+9VDC

+4.5 VDC

C4 10 PF

C5 2.9-35 PF 5MC

Y3 5 MC

J3

1 MC/S Δf 1X10⁻¹⁰/DIV

R3 20K 2 CW

R2 100

Q2 2N1038-1/ 2N2552

+35VDC

XY4

+22 VDC REG

J4

J7 ANTENNA

J8 COHERENT 100 KC/S

RECORD CONNECTOR J6

RECORD CONNECTOR

1. COHERENT 100KC/S
2. STANDARD 10 KC/S
3. COHERENT 10 KC/S
4. ΔT RECORD
5. ΔT RECORD REF
6. SERVO DISABLE
7.
8
9.
10
11
12
13
14. +4.5 BIAS
15. +9V POWER
16. GROUND

FREQUENCY (S3)
1. 20 KC/S
2. CAL
3. 60 KC/S

RECORDER (S4)
1. ΔT
2. db
3. Q

J5

P5

M1

Q1 2N1038-1/ 2N2552

R1 100

+16 VDC

C8 1000MF, 25V

C9 1000MF 25 V

CR1 IN3193

CR2 IN3193

CR3 IN3193

CR4 IN3193

N.C.

T1

S1

POWER

F3 1/2A

F2 1A

F1 1/2A

115 VAC

TB1 +12V +24V GND

Y2 1000 KC/S

INPUT C2 2.9-35 PF

C1 10 PF

RECEIVER STANDARD

EXT 55 INT

R4 15

J10 EXTERNAL STANDARD IN 1 MC/S

J13 1 MC/S (FRONT PANEL)

J12 INTERNAL STANDARD OUT 1 MC/S

J11 100 KC/S

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
DO NOT SCALE DRAWINGS

TOLERANCES

DECIMALS | FRACTIONS | ANGLES

MATERIAL

NEXT ASSY | USED ON

APPLICATION

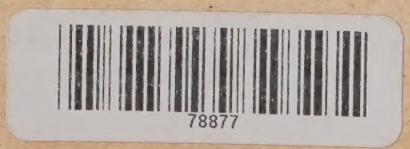
ENGINEER	C. SLover	10/5/64
CHECKED		
DRAFTSMAN	Contreras	

TRACOR, INC. AUSTIN, TEXAS

892 CHASSIS SCHEMATIC

SIZE	CODE IDENT NO.		
4	7056	76	A

SCALE NONE SHEET OF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